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TRANSMITTAL OF PRIORITY DOCUMENT

SIR:

Appended hereto is a certified copy of Priority Document EP 01103060.8 filed February 9, 2001.

Applicant requests that this document be made of record in the above identified application.

Respectfully submitted,
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CERTIFICATE OF MAILING

I hereby certify that the foregoing Transmittal of Priority Document is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Hon. Commissioner of Patents, Washington, D.C. 20231, on the date indicated below:

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The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

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Influenza Viruses with Enhanced Transcriptional and Replicational Capacities

The present invention provides human influenza viruses comprising an RNA-sequence encoding a modified RNA-polymerase, a process for the preparation thereof, pharmaceutical compositions comprising said human influenza viruses and their use for gene transfer into mammalian cells, for *ex vivo* gene transfer into antigen-presenting cells, such as dendritic cells, for *in vivo* somatic gene therapy, or *in vivo* vaccination purposes. The invention also relates to other non-avian influenza viruses, including equine, porcine (swine) influenza viruses.

Background of the Invention

The RNA-dependent RNA-polymerase of the influenza virus, which is comprised of three viral polymerase (P) subunits, PB1, PB2 and PA, catalyses the synthesis of both viral mRNA (transcription) as well as complementary RNA and progeny viral RNA (replication) in infected cells (Lamb R.A., Krug R.M. Fields Virology 3: pp 1353-1445 (1996)). In the virion the enzyme is found tightly associated at each of the eight different species of viral RNAs (vRNAs) with their 5' and 3' ends, which in combination constitute the promoter structure, while all other parts of the vRNA molecules are covered by a large number of influenza nuclear protein (NP) molecules, one per 27 nucleotides in average (Ortin J. et al., Options for the Control of Influenza IV; Osterhaus A., ed. in print (2000)), altogether described as the viral RNP complexes. Upon infection the vRNPs are released from the virion and transferred into the nucleus of the infected cell, where viral mRNA synthesis is initiated by the promoter-associated enzyme according to the cap-snatching scheme, i.e. employing primer oligonucleotides that are derived from cellular mRNAs or hnRNAs by endonucleolytic cleavage (Krug R.M. et al., The Influenza Viruses, Plenum Press, New York, NY, pp. 1-87 (1989)). While during progression

of mRNA synthesis along the vRNA template molecule its 3' end loses contact to viral polymerase, the enzyme maintains its tight association with the 5' vRNA end throughout the entire first and all consecutive rounds of transcription. Synthesis of mRNA molecules is terminated via poly-adenylation at a 5' promoter sequence-adjacent series of 5 or 6 uridine template residues, i.e. the very 5'-terminal sequence covered by the enzyme is not transcribed into viral mRNA.

The conformation of the vRNA promoter sequence in its association with viral polymerase has been demonstrated by reverse genetic analysis to constitute a "corkscrew" structure, with exposed single-stranded tetranucleotide sequences supported by two intra-strand basepairs in both the 5' and 3' branches of the promoter sequence. In the course of that analysis also several promoter-up variants of the terminal vRNA sequence have been described, mainly through base-*pair* exchanges involving positions 3 and 8 from the 3' end, and positions 3 and 8 from the 5' end (Neumann G., Hobom G., J. Gen Virol. 76 (Pt 7):1709-17 (1995); Flick R. et al., RNA, 2(10):1046-57 (1996); Flick R., Hobom G., J. Gen Virol. 80(Pt 10):2565-72 (1999); WO96/10641). With typical increases in reporter gene or other foreign gene expression of up to 20 times the wildtype promoter yields, such influenza virus vectors range also four- to fivefold above the expression level achieved with plasmid DNAs under control of the standard cytomegalovirus early promoter (p_{CMV}).

However, there are two limitations to this effect: 1.) That gain of 20 times the wildtype promoter level in expression efficiency is true for inserts up to 1500 nucleotides in size under control of influenza promoter-up variants, while further increases in insert size up to 3000 nucleotides will steadily reduce that gain in promoter efficiency, and only low expression rates have been achieved with inserts 4000 nucleotides in length (M. Azze, G. Hobom, unpublished). 2.) Such increased expression rates have only been obtained as long as avian influenza virus (fowl plague viruses, FPV: H7N7) or rather viral polymerases derived from FPVs were used

together with promoter-up sequence variants; no such effect has been seen with other influenza viral strains tested : WSN (H1N1); Asia (H2N2) or Victoria (H3N2) (Hoffmann E., Hobom G., unpublished data).

Thus, what is needed for an application of those biotechnologically valuable increased expression rates exerted upon foreign genes in human cells or organs is a transfer of the FPV Bratislava polymerase properties in recognizing such promoter sequence variations into the respective polymerase coding sequences of other influenza viruses, able to replicate efficiently in human tissue. In addition, the use of H1N1 (WSN; PR/8) or H3N2 (Victoria or other) viral variants instead of FPV, if possible would constitute a gain in biological safety. Due to the amino acid sequence of H1 and H3 hemagglutinin-carrying viruses these become activated for infection only through cleavage by a narrow spectrum of proteases, as opposed to hemagglutinin H7 which becomes activated also through cleavage by a number of additional, ubiquitous proteolytic enzymes.

Summary of the Invention

It was found that specific modifications of the RNA sequence within the respective viruses which code for the RNA-polymerase, in particular for the PB1 subunit thereof – so as to code for a polypeptide chain having a higher similarity with FPV Bratislava RNA-polymerase – provides viruses capable of recognition of vRNA and cRNA promoter sequence variations (the so called promoter-up variants mentioned above) leading to an increase in transcription and/or replication initiation rates. The present invention thus provides

(1) a human influenza virus comprising an RNA-sequence encoding a modified RNA-polymerase which differs from the wild-type RNA-polymerase of said human influenza virus in that at least one of the amino acid residue(s) distinguishing the wild-type RNA-polymerase of said human influenza virus from FPV Bratislava RNA-polymerase has been replaced with the respective amino acid residues of FPV Bratislava RNA-polymerase ("FPV Bratislava" and "FPV Bratislava RNA-polymerase" are

hereinafter also shortly referred to as "FPV" and "FPV RNA-polymerase", respectively);

(2) in a preferred embodiment of the influenza virus defined in (1) above, the modified RNA-polymerase is capable of recognition of segments with modified vRNA promoter sequences resulting in an enhanced rate of transcription and/or replication, relative to said wild-type influenza virus RNA-polymerase;

(3) in a preferred embodiment of the influenza virus defined in (2) above, the influenza virus is suitable for high yielding expression of one or more foreign recombinant or altered viral proteins, preferably said influenza virus contains

(i) one or more segment(s) with a foreign recombinant or altered viral gene sequence in addition to the RNA segments of the normal viral genome (additional segment) or partially replacing them (hereinafter replacing segment), whereby the additional segment(s) and replacing segment(s) comprise the foreign or altered gene encoding the protein to be expressed in monocistronic arrangement and have modified vRNA promoter sequences as defined in (2) above; and/or

(ii) one or more bicistronic vRNA segment(s), preferably in ambisense or in tandem arrangement, whereby the bicistronic vRNA segment(s) has/have foreign gene(s) encoding the protein(s) to be expressed and being in covalent linkage with one of the authentic viral genes, preferably the neuraminidase gene, and has/have modified vRNA promoter sequences as defined in (2) above;

(4) in a preferred embodiment of the influenza virus defined in (3) above, the influenza virus has at least one segment coding for one or more foreign (or altered proper) genes in monocistronic arrangement;

(5) in a preferred embodiment of the influenza virus defined in (3) above, the influenza virus is genetically stable in the absence of any helper virus and comprises at least one viral RNA segment being an ambisense RNA molecule (hereinafter "ambisense RNA segment") and containing one of the standard viral genes in sense orientation and a foreign, recombinant

gene in anti-sense orientation, or *vice versa*, in overall convergent arrangement;

(6) in a preferred embodiment of the influenza virus defined in (3) above, the influenza virus is genetically stable in the absence of any helper virus and comprises at least one viral RNA segment being a bicistronic RNA molecule coding for two genes in tandem arrangement (hereinafter "tandem RNA segment"), in said tandem RNA segment one of the standard viral genes being in covalent junction with a foreign, recombinant gene and said tandem RNA segment having an upstream splice donor and a downstream splice acceptor signal surrounding the proximal coding region;

(7) a non-avian, non-human influenza virus, preferably an equine or a porcine influenza virus, comprising an RNA-sequence encoding a modified RNA-polymerase which differs from the wild-type RNA-polymerase of said non-avian, non-human influenza virus in that at least one of the amino acid residue(s) distinguishing the wild-type RNA-polymerase of said non-avian, non-human influenza virus from FPV Bratislava RNA-polymerase has been replaced with the corresponding amino acid residue(s) as present in FPV Bratislava RNA-polymerase, preferably said influenza virus is as defined in (2) to (6) above;

(8) a process for preparing the influenza virus as defined in (1) to (7) above, which comprises replacing the RNA-sequence encoding the wild-type RNA-polymerase of said influenza virus with an RNA-sequence encoding the modified RNA-polymerase;

(9) in a preferred embodiment of the process defined in (8) above, the process is suitable for preparing PB1-chimeric viruses as defined in (1) and (2) above as well as recombinant viruses as defined in (1) to (7) above said viruses being generated via cotransfection of up to eight cDNA plasmids containing the viral cDNAs, or chimeric (segment 2: PB1) and bicistronic recombinant (segment 6: NA/foreign gene) cDNA sequences instead, in such a way that they are transcribed *in vivo* by both RNA-

polymerase I and RNA-polymerase II and jointly give rise to progeny viruses according to the plasmid insert design;

(10) a pharmaceutical composition comprising the influenza virus as defined in (1) to (7) above;

(11) the use of the influenza virus as defined in (1) to (7) above for preparing an agent

(i) for gene transfer into cells, preferably into mammalian cells, more preferably into human cells, by viral infection;

(ii) for gene transfer into antigen-presenting cells and the use of the obtained product for *ex vivo* immunotherapy;

(iii) for *in vivo* somatic gene therapy;

(iv) for *in vivo* vaccination, including therapeutic and prophylactic vaccination;

(v) for eliciting an immune response, including the induction of T-cell response;

(vi) for treating a growing tumor or a chronic infectious disease;

(12) a method for

(i) gene transfer into cells, preferably into mammalian cells, more preferably into human cells, by viral infection;

(ii) gene transfer into antigen-presenting cells and the use of the obtained product for *ex vivo* immunotherapy;

(iii) *in vivo* somatic gene therapy;

(iv) *in vivo* vaccination, including therapeutic and prophylactic vaccination;

(v) eliciting an immune response, including the induction of a T-cell response, preferably a CD4+ T-cell response, a CD8 T-cell response or both, or the induction of an antibody response;

(vi) treating a growing tumor or a chronic infectious disease;

(vii) preparing a vaccine;

(viii) preventing and/or treating influenza;

which comprises contacting the cells (including human or mammalian cells), the antigen-presenting cells, the person or the patient in need for vaccination, influenza treatment or for somatic gene therapy, or cell cultures with the influenza virus as defined in (1) to (7) above;

(13) a method for the production of proteins or glycoproteins which comprises utilizing the influenza virus as defined in (1) to (7) above as expression vector;

(14) the use of the influenza virus as defined in (1) to (7) above for preparing agents

(i) for transfer and expression of foreign genes into cells infected by such viruses, or

(ii) for transfer and expression of RNA molecules into cells infected by such viruses, preferably the RNA molecules to be expressed are antisense sequences or double-strand sequences relative to the target cell cellular mRNA molecules, and/or the agent is suitable for sequence-specific gene silencing, preferably by antisense RNA or RNA interference mechanisms such as ribozyme cleavage of target RNAs;

(15) a method for transfer and expression of foreign genes into cells, and for transfer and expression of RNA molecules into cells, which method comprises infecting the cells with the influenza virus as defined in (1) to (7) above;

(16) the use of the influenza virus as defined in (1) to (7) above for preparing agents for immunotherapy, preferably for autologous immunotherapy;

(17) a method for an immunotherapy which comprises *ex vivo* infection of immune cells, preferably dendritic cells, with the influenza virus as defined in (1) to (7) above, and introduction of the transduced cells into the patient;

(18) a method to elicit an immune response directed against an antigen, comprising the steps of introducing the influenza virus as defined in (1) to (7) above, preferably the human influenza virus as defined in (1) to (6) above, into a cell or administering it to a mammal, wherein said influenza virus contains at least one foreign gene encoding the antigen;

(19) a vaccine for therapeutic or prophylactic purposes which is

(a) a human influenza virus vaccine comprising a human influenza virus as defined in (1) to (6) above or in (18) above, preferably said human

influenza virus encodes the antigen for a membrane protein and in addition contains the membrane protein in the viral envelope; or

(b) a non-human influenza virus vaccine, preferably an equine or porcine influenza virus vaccine, comprising a virus as defined in (7) above;

(20) transduced cells, preferably antigen-presenting cells, obtainable by the method described in (12), option (i) or (ii) above;

(21) a vaccine comprising transduced cells as defined in (20) above, preferably comprising transduced antigen-presenting cells, more preferably transduced dendritic cells, and most preferably mature dendritic cells, wherein said antigen-presenting cells are transduced *in vitro*; and

(22) a method to identify a polynucleotide sequence encoding at least one HLA-restricted epitope comprising the steps of

- (a) preparing a gene bank or a cDNA bank from the cell or the microorganism to be tested;
- (b) incorporating the cDNA or the DNA of the gene bank into the genome of the influenza virus as defined (1) to (7) above to yield recombinant virus particles,
- (c) infecting immortalized autologous cells, which are capable of expression of HLA-class I molecules and/or HLA-class II molecules on their surface, with the recombinant virus particles obtained in step (b),
- (d) expressing the proteins encoded by said cDNA or said DNA of the gene bank in the autologous cells and presenting the fragments of the proteins produced by the autologous cells or the cell surface in connection with HLA molecules;
- (e) co-cultivating T-cells with the autologous cells; and
- (f) stimulating the T-cells by such autologous cells which present antigens on their surface, whereby said antigens are recognized by the T-cells.

Short Description of the Figures

Figure 1: shows a comparison of variant amino acid positions in the PB1 segment of influenza A viruses, such as FPV, WSN and others, the

numbering being relative to WSN. The underlined amino acid residues representing substitutions present exclusively in WSN, while amino acid residues in bold print point out those substitutions observed only in FPV Bratislava. The complete RNA sequence of the PB1 segment of WSN is shown in SEQ ID NO: 24 (nucleotides 191 to 2461) and the corresponding polypeptide is shown in SEQ ID NO:25, while the complete sequence of FPV-PB1 is shown in SEQ ID NO:22, and the corresponding polypeptide constitutes SEQ ID NO:23.

Figure 2: Chimeric structure and determination of promoter-recognition proficiency of a first set of WSN/FPV-PB1 constructs; Sections of FPV sequence within otherwise WSN-derived PB1 are indicated in heavy lining; WSN (pPolI-WSN-PB1) and FPV (pHL3115= WF1; pHL1844) are included for comparison.

Figure 3: Chimeric structure and determination of promoter-recognition proficiency of a second, more detailed set of WSN/FPV constructs.

Figure 4: shows FPV-Bratislava-PB1, the exact 5169 bp nucleotide sequence thereof is shown in SEQ ID NO:22 (nucleotides 191 to 2461 thereof encoding the PB1 segment of FPV Bratislava wild-type RNA-polymerase shown in SEQ ID NO:23).

Figure 5: shows WSN-PB1, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:24 (nucleotides 191 to 2461 thereof encoding the PB1 segment of WSN wild-type RNA-polymerase shown in SEQ ID NO:25).

Figure 6: shows plasmid pHL3102, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:26 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:27, with the following "major" modifications: L628M, V644A, and T741A and the following "minor" modifications: I576L, H584R, N633S, D636E, I645V, N654S).

Figure 7: shows vector pHL3103, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:28 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:29, with the following "major" modifications: S384P and L396I, and the "minor" modifications as pointed out in Fig. 1, positions 52 to 473).

Figure 8: shows vector pHL3130, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:30 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:31, with the following "major" modifications: S384P, L396I, L628M, V644A and T741A, and the "minor" modifications according to Fig. 1, positions 298-654).

Figure 9: shows vector pHL3131, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:32 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:33, with the following "major" modifications: S384P and L396I, and the "minor" modifications according to Fig. 1, positions 298-473).

Figure 10: shows vector pHL3203, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:34 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:35, with the following "major" modifications: L628M, V644A and T741A, and the "minor" modifications according to Fig. 1, positions 633-654).

Figure 11: shows vector pHL3204, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:36 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:37, with no "major" modifications and the following "minor" modifications: I576L and H584R).

Figure 12: shows vector pHL3246, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:38 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:39, with no "major" modifications and the following "minor" modifications: I298L and I364L).

Figure 13: shows vector pHL3247, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:40 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:41, with "major" modifications S384P and L396I, and the following "minor" modifications: D383E, H431T, N464D and L473V).

Figure 14: shows vector pHL3258, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:42 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:43, with "major" modification S384P and "minor" modification D383E).

Figure 15: shows vector pHL3259, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:44 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:45, with "major" modification S384P and the following "minor" modifications: D383E, I576L and H584R).

Figure 16: shows vector pHL3268, the exact 5169 bp nucleotide sequence is shown in SEQ ID NO:46 (nucleotides 191 to 2461 thereof encoding the modified WSN RNA-polymerase PB1 segment shown in SEQ ID NO:47, with the following "major" modifications: S384P, L628M, V644A and T741A, and the following "minor" modifications: D383E, N633S, D636E, I645V, N654S).

Detailed Description of the Invention

In the present application "human influenza virus" includes all types of non-avian influenza viruses, including human, equine and porcine

influenza viruses and the like, with human influenza viruses being the preferred ones. In the present application the influenza virus is also referred to as "vector", "expression vector" or "virus vector".

"Organism" embraces prokaryotic and eukaryotic systems as well as multicellular systems such as vertebrates (including mammals) and invertebrates, plants, etc. The term "cell" includes all types of cells of the "organism" defined above. A "mammal" according to the present invention includes humans and animals, "mammalian cells" include human cells and animal cells.

"Infected cells" and "infecting cells" according to the present invention also include "abortively infected cells" and "abortively infecting cells", respectively.

"Monocistronic" and "monocistronic arrangement" according to the present invention refers to a viral RNA segment, vRNA, cRNA or mRNA having one independent gene in "regular" (or "native") arrangement, while "bicistronic" according to the present invention refers to a viral RNA segment, vRNA, cRNA or mRNA that includes two independent genes in covalent junction (in a preferred embodiment of the present invention one of these genes is of viral origin, while the other one codes for a foreign, recombinant gene product).

In embodiment (1) of the invention as defined above, the influenza virus is preferably selected from influenza A including strains of type H1N1, H2N2 and H3N2, influenza B and influenza C, and more preferably is an influenza A type H1N1, including WSN/33, PR8/34 or the like, an influenza A type H2N2, including Asia/57 or the like, or an influenza A type H3N2, including Victoria/68 or the like.

It is moreover preferred that the at least one distinguishing amino acid residue is located within the PB1 segment of the virus. Possible substitutions within the PB1 segment can be derived from Fig. 1. Among those, and specifically for WSN, it is preferred to replace specifically one or more of the amino acid residues at positions 384, 396, 628, 644 and 741

(based on the numbering of WSN-PB1 shown in SEQ ID NO:25) which are also designated "major modifications" or "major replacements" with the respective FPV Bratislava amino acid residues (see Fig. 1). Preferably, the influenza virus strain used is WSN-K68 carrying five distinguishing amino acids. As an alternative to or in addition to those major modifications the PB1 may have the "minor" modifications as set forth in Fig. 1, namely at positions 52, 54, 105, 175, 208, 298, 364, 383, 431, 464, 473, 576, 584, 633, 636, 645 and 654. Most preferred PB1 segments are those coding for the amino acid sequences shown in SEQ ID NO: 27, 35, 43, 45 or 47.

The RNA-polymerase catalytic subunit PB1 of influenza virus WSN has been adapted by mutagenization to recognize and respond to the various nucleotide exchanges introduced in the vRNA promoter sequence that constitute promoter-up mutations in both transcription and replication. This result has been achieved through exchange of vRNA or indeed of plasmid cDNA sections within the coding sequence for polymerase subunit PB1 (segment 2) of influenza virus WSN (H1N1) using the corresponding sections derived from FPV Bratislava (H7N7) segment 2. Because of the large number of identical amino acids within both homologous segments and the rather small fragments being switched in that construction of chimeric PB1 the genetic transfer is equivalent to an introduction of a small number of amino acid substitutions within the PB1 polypeptide chain of WSN viral RNA-polymerase, while subunits PB2 and PA remain unchanged. In principle those amino-acids required for recognition of the rather minute promoter-up variations in the template molecules should be involved in direct interactions with the respective parts of the promoter structure, in particular with nucleotides 3 and 8 from the 3'-end, which constitute one of the base-pairs in the "cork-screw" proximal promoter element. The amino acid substitutions required for that purpose are distributed over two regions that broadly are known to be involved in vRNA and cRNA binding, respectively, in two separate sections in the PB1 polypeptide chain to the left and right of the enzymatic reaction centre. No difference has been observed in virus stability, viral yields or other

properties in the PB1 variants as compared to standard PB1 containing WSN virus, as long as only wildtype promoter sequences are present in all of the influenza virus RNA segments, but segments carrying promoter-up variant sequences are transcribed and replicated at elevated rates, resulting in an up to 14 times the wildtype promoted expression level.

The generation of recombinant influenza viruses was hampered for a long time by the fact that the virus has a segmented RNA genome. The development of the RNA-polymerase I technique allows the generation of recombinant viruses with additional genomic segments capable of expressing complete heterologous genes (G. Neumann et al., *Virology* 202, 477-479 (1994)), which was built around the *in vivo* synthesis of recombinant vRNA molecules by cellular RNA-polymerase I transcription of the respective template cDNA constructs. Modified terminal viral RNA sequences (hereinafter "promoter-up mutations" or promoter-up variants") have been designed by nucleotide substitutions (Neumann and Hobom, *Mutational analysis of influenza virus promoter elements in vivo*, *J. Gen. Virol.* 76, 1709-1717 (1995); WO 96/10641). The above promoter-up variants carry up to five nucleotide substitutions (in promoter-up variant 1920; see Flick and Hobom, *J. Gen. Virol.* 80, 2565-2572 (1999)). When these promoter-up variants are attached to a recombinant ninth vRNA segment its increased transcription and amplification rates will not only compensate for the losses suffered spontaneously, but even cause accumulation of the foreign vRNA segment during simple viral passaging, in the absence of any selection.

As set forth in embodiment (2) above, a preferred method of the invention is where the recombinant virus contains terminal viral RNA sequences, which are active as promoter signal, have been modified by nucleotide substitution in up to 5 positions, resulting in improved transcription rates (of both the vRNA promoter and the cRNA promoter as present in the complementary sequence) as well as enhanced replication and/or expression rates relative to the wild-type sequence. Said modified terminal

viral RNA sequences differ from the wild-type sequence in that in said vRNA segment the 12 nucleotide conserved influenza 3' terminal sequence has been modified by replacement of one to three nucleotides occurring in said sequence at positions 3, 5 and 8 relative to the 3' end by other nucleotides provided that the nucleotides introduced in positions 3 and 8 are forming a base pair (i.e., if the nucleotide position 3 is G, than that in position 8 is C; if the nucleotide in position 3 is C, than that in position 8 is G; etc.).

The 3' conserved regions of the wild-type influenza virus have the following sequences:

Influenza A: (5')-CCUGCUUUUGCU-3'

Influenza B: (5')-NN(C/U)GCUUCUGCU-3'

Influenza C: (5')-CCUGCUUCUGCU-3'.

Moreover, the 13 nucleotide conserved influenza 5'-terminal sequence may be modified by replacement of one or two nucleotides occurring in said sequence at positions 3 and 8 by other nucleotides, again provided that the introduced nucleotides are forming a base pair. The 5' conserved regions of the wild-type influenza virus have the following sequences:

Influenza A: 5'-AGUAGAAACAAGG

Influenza B: 5'-AGUAG(A/U)AACA(A/G)NN

Influenza C: 5'-AGCAGUAGCAAG(G/A):

Preferred influenza viruses of the invention are those wherein in the 3' conserved region the replacements G3A and C8U have been performed, more preferred are those where also the replacement U5C has been performed (the above mutations are annotated relative to the 3' end; such counting from the 3' end is also indicated by a line on top of the digit, e.g., G $\bar{3}$ A). Another preferred influenza virus mutant comprises the 3'-terminal nucleotide sequence G3C, U5C and C8G (relative to the 3' end) resulting in the following 3' terminal nucleotide sequence (5')-CCUGGUUCUCCU-3'. Among the influenza viruses defined hereinbefore those having a 3'-

terminal nucleotide sequence of (5')-CCUGUUUCUACU-3' are most preferred. In case of an influenza A virus the segment may further have the modifications U3A and A8U in its 5' terminal sequence, in case of influenza C it may have the modifications C3U and G8A in its 5' terminal sequence. The most preferred influenza viruses of the present invention comprise the following general structures:

Influenza A (mutant pHL1102):

5'-AGUAGAAACAAGGNNNU₅₋₆..(860-2310 ntds)..N'N'N'CCUGUUUUUACU-3'

Influenza A (mutant pHL1104):

5'-AGUAGAAACAAGGNNNU₅₋₆..(860-2310 ntds)..N'N'N'CCUGUUUCUACU-3'

Influenza A (mutant pHL1920):

5'-AGAAGAAUCAAGGNNNU₅₋₆..(860-2310 ntds)..N'N'N'CCUGUUUCUACU-3'

Influenza A (mutant pHL1948):

5'-AGUAGAAACAAGGNNNU₅₋₆..(860-2310 ntds)..N'N'N'CCUGGUCUCCU-3'

Influenza B:

5'-AGUAG(A/U)AACA(A/G)NNNNNU₅₋₆..(860-2310 ntds)..N'N'N'N'N'(C/U)GUUUCUACU-3'

Influenza C:

5'-AGUAGUAACAAG(G/A)GU₅₋₆..(860-2310 ntds)..CCCCUGUUUCUACU-3'

In the above structures the variables are defined as follows:

- (1) Underlined letters show the required mutations relative to the wild-type sequence for preparing a promoter mutant with enhanced properties;
- (2) enlarged A in position 10 in the 5'-part of the sequence: unpaired A residue, bulge-forming;
- (3) (A/G) in one position: different isolates or single segments with alternative sequence at the respective position, which are functionally interchangeable;
- (4) N and N': positions undefined, but base-paired relative to each other because of complementarity between the 5' and 3' termini, different among the 8 segments, but constant for each segment throughout all viral isolates;
- (5) (860-2310 ntds): the lengths of the authentic viral RNA segments, in case of segments with foreign genes increased up to 4,000 nucleotides.

Introduction of promoter-up recognition properties into standard human viruses of types H1N1 (WSN, PR/8), H2N2 (Asia), H3N2 (Victoria, Aichi, etc.) or other through PB1 mutagenization solves the problem of constructing influenza virus vectors other than FPV-derived bearing the property of expressing foreign proteins at very high rates that are suitable for expression of foreign genes in human cells or tissues including somatic gene therapy and therapeutic or prophylactic immunization.

The influenza A virus genome consists of eight segments of negative-strand viral RNA, i.e. their polypeptide coding frames are present in those vRNAs only in antisense orientation. They range in size from 890 nucleotides (segment 8) to 2341 nucleotides (segments 1 and 2). Among these the three largest segments code for three polypeptide chains that together constitute the viral RNA-polymerase: PB1, PB2 and PA, jointly comparable with RNA-polymerases as present in non-segmented negative-strand RNA viruses, which often are encoded in around 5000 nucleotides of vRNA.

Out of the three polymerase subunits that stay attached to each other in constituting the viral enzyme as present in the RNP complexes both in the virion and in the nucleus of the infected cell, the PB1 subunit can be regarded as the central catalytic subunit, since it carries all the enzymatic functions known to date: NTP binding, RNA chain elongation, and endonucleolytic cleavage (of the cellular RNA that thereafter is used as a primer for mRNA synthesis). In addition, PB1 also includes template binding sites for both the vRNA 5' and 3'-terminal sequences as well as the cRNA 5' and 3'-terminal regions (Li M.L. et al., EMBO J. Oct 1; 17(19):5844-52 (1998); Gonzales S., Ortin J., EMBO J. Jul 1;18(13):3767-75 (1999)), i.e. for the various promoter elements, and finally is known to have attachment regions for both PB2 (at its C-terminus) and PA (at its N-terminus), which in turn are not directly attached to each other (Toyoda T. et al., J. Gen. Virol. Sep;77(Pt 9):2149-57 (1996); Gonzales S. et al., Nucleic Acids Res., Nov. 15;24(22):4456-63

(1996)). Subunit PB2 is known to specifically bind to the 5'-cap structure of cellular mRNA and hnRNA molecules, and thereby initiate the cap-snatching mode of viral mRNA transcription (Ulmanen I. et al., Proc. Natl. Acad. Sci. USA Dec.; 78(12):7355-9 (1981); Shi L. et al., Virus Res. Jun.;42(1-2):1-9 (1996)). Subunit PA which is known to act as a phosphoprotein appears to have a role in cRNA and vRNA synthesis, i.e. in replication, and possibly also in the corresponding switch from mRNA to cRNA synthesis (Mahy B.W.J., Genetics of Influenza Viruses, Springer Verlag, Wien, pp. 192-253 (1983); Sanz-Esquerro J.J. et al., J. Gen Virol. Mar;79(Pt 3):471-8 (1998)). Somewhat aberrantly PA if expressed in the absence of PB1 and PB2 appears to lead to proteolytic degradation of co-expressed proteins (Sanz-Esquerro J.J. et al., J. Gen Virol. Mar;79(Pt 3):471-8 (1998)).

Nuclear translocation signals have been determined within all three polypeptides, in accordance with the nuclear localization of viral polymerase in infected cells (Nieto A. et al., J. Gen. Virol. Jan;75(Pt 1):29-36 (1994)).

Interaction of viral polymerase with the 5' and 3' ends of vRNA or cRNA has been detected in one set of experiments through binding of ^{32}P -5'-oligonucleotides, 16-18 residues in size, which carried a single *thio*-uridine in 5' position 15 or in 3' position 10, respectively, followed by UV cross-linking and determination of ^{32}P -carrying peptides. In this way the 5' vRNA sequence was observed to bind primarily to the PB1 polypeptide chain at the region centred around arginine residues 571 and 572, while the 3' vRNA model sequence attaches to the region PB1: 249-256, which includes two phenylalanine residues at positions 251 and 254 (Li M.L. et al., EMBO J. Oct 1; 17(19):5844-52 (1998)). In addition to primary vRNA binding sites as determined by UV cross-linking, in another approach secondary binding regions have also been observed for vRNA in the N-terminal region (1-139) and in the C-terminal region (493-757) using PB1 deletion variants. And while one of the cRNA binding sites determined in

the same way overlaps in the N-terminal region (1-139) with vRNA binding, a second cRNA binding region is located in the central section (267-493) rather than in the C-terminal region (493-757) as detected for vRNA binding (Gonzales S., Ortin J., EMBO J. Jul 1;18(13):3767-75 (1999)).

A sequence comparison between the PB1 polypeptide chains of FPV Bratislava (H7N7) and WSN (H1N1), proficient and deficient in recognizing the promoter-up variant sequences, revealed a divergence in 22 out of 757 amino acid positions. Upon extending that comparison to include PB1 sequences also from other influenza viruses such as PR/8 (H1N1), Asia (H2N2) and Victoria (H3N2) that number of divergent positions could tentatively be reduced by 11 amino acids, which are present only in WSN and not in any other PB1 sequence in a collection of over 150 viruses representing a large variety of influenza strains. Whereas the same residue is invariably present in the respective positions both in FPV Bratislava leading to proficiency and throughout all (or most, positions 584 and 741) other isolates leading to deficiency in recognizing the promoter sequence variants. Among the remaining 11 divergent positions seven of the FPV specific residues appear in several, but not in all other viral isolates, while four amino acid residues are specific for FPV Bratislava, and do not appear anywhere else: S384P, L396I, L628M, V644A. While the divergent positions in this category are most attractive in the search for specific properties of FPV, at this stage it cannot be ruled out that others among the altogether nine inconsistently variable amino acid residues may at least assist structurally or functionally in recognition of the variant promoter structures, in particular true for D383E because of its adjacent position relative to S384P. The apparently most important five divergent positions cluster in two groups, in the central region (383-396) not very far from the centre of polymerization activity, and in a near C-terminal region (628-741), i.e. within the brackets of the C-terminal vRNA binding region (see Fig. 1).

In a first step of analysis we have created WSN-FPV reassortant viruses carrying either a single one of the FPV subunit vRNAs in an otherwise all WSN background, or including the three FPV polymerase subunit vRNAs simultaneously. This was achieved via direct generation of influenza viruses from a set of cloned cDNAs (Neumann G. et al., Proc. Natl. Acad. Sci. USA, Aug. 3;96(16):9345-50 (1999)) designed to be transcribed *in vivo* by cellular RNA-polymerase I into eight individual viral RNA molecules (Neumann G. & Hobom G., J. Gen. Virol. Jul;76 (Pt 7):1709-17 (1995)), which were co-transfected together with four expression plasmids for early influenza virus proteins (PB1, PB2, PA, NP; Pleschka S. et al., J. Virol. Jun;70(6):4188-92 (1997)). All four viral reassortants turned out to be viable even if not yielding a full titer as compared to parental WSN or FPV. They were used to determine which of the three FPV polymerase subunits was responsible for recognition of the promoter-up variant sequences and caused increased expression rates of reporter genes controlled by them. Both reassortant viruses carrying either all three polymerase subunits originating from FPV, or carrying only the PB1 subunit derived from that avian influenza virus showed increased chloramphenicol acetyltransferase activity in the transfected cells as well as during consecutive steps of viral propagation with promoter-up variant 1104-CAT vRNAs, while the two reassortants containing either FPV-PB2 or FPV-PA in an otherwise WSN background of vRNA segments did not. From these data we conclude that it is indeed the FPV-PB1 subunit, already known from the above to interact with the vRNA and cRNA terminal sequences, i.e. the promoter structures, which is also recognizing the basepair and nucleotide substitutions present in the promoter-up variants. Another result derived from these initial experiments is the observed potential for free exchange of viral polymerase P-subunits between FPV and WSN viruses without major reduction in activity rates due to incompatibility.

Starting out from the FPV/WSN sequence comparison of PB1 and the present knowledge about the location of its functional domains a first

round of chimeric PB1 clones was designed, which carried sections of both FPV-PB1 and WSN-PB1 at approximately one third and two thirds of the either polypeptide chain, see Figure 2. The results confirm that the N-terminal section even though it is known to include one of the binding sites for the vRNA and the cRNA terminal sequences is not involved in promoter variant recognition, as was suggested already by the small number of amino acid exchanges, which also might be regarded to be conservative, and because all of them show up (individually) in the majority of non-proficient viruses other than WSN: R52K, R54K, T105N, N175D and R208K. Instead, the chimeric PB1 protein carrying the C-terminal FPV section (492-757) attached to the N-terminal part of the WSN polypeptide (in pHL3102), and the PB1 chimera pHL3131 carrying a central FPV region (241-492) surrounded on either side by WSN sequence resulted in high or moderately high recognition of variant promoter sequences, in accordance with being divergent by 8 or 9 amino acid exchanges, respectively. In the extended comparison of proficient versus deficient viral PB1 sequences 2 and 2 substitutions thereof might be regarded to be "major" exchanges, i.e. being present only in FPV Bratislava. Because of the experimental data described below substitution T741A may also be regarded to be in the "major" (or main assisting) category, even though the alanine residue in this position is also present in several other, non-proficient viruses.

In a second round of PB1 chimera constructions the previously used central and C-terminal FPV sections of 34 % the entire length in both pHL3131 and pHL3102 have been divided further into halves, i.e. with regard to the number of amino acid divergencies remaining in pHL3131 and pHL3102 relative to full-size WSN-PB1. In this way pHL3204 constitutes the FPV:492-599 hybrid PB1 clone, pHL3203 the FPV: 599-757 containing polypeptide chain, pHL3256 carries an FPV section extending from position 241 to position 374, and pHL3257 contains FPV sequence from position 374 to 492, see Figure 2. In addition, a selected small section of FPV-PB1 sequence (374-394) covering a most tightly clustered

group of two amino acid exchanges relative to WSN-PB1: D383E, and S384P has also been inserted into WSN-PB1 both on its own: pHL3258, and in combination with a second section of FPV-PB1: 492-599 (pHL3259) or 599-757 (pHL3268), i.e. the same regions as present individually in pHL3204 or pHL3203. As documented in Figure 3, it is the latter combination of two short, separate sections of FPV carrying in one section one "major" and one "minor" substitutions, and in the other three plus four amino acids in these categories exchanged, which gave the best results in recognition of promoter-up variant 1104, with rates above each of the individual constituents, pHL3203 or pHL3258, and at 70% the level of FPV polymerase itself (see pHL1844).

The difference remaining may be due to a negative effect caused by one or more of the amino acid substitutions present in pHL3268 resulting from sterical interactions with other parts of the WSN-PB1 molecule, while that respective amino acid residue may or may not be involved directly in promoter sequence recognition, too. In the latter case the promoter activity might be further increased upon determination and elimination of that disturbing residue among the few amino acid substitutions remaining at present. In the other case, i.e. with both effects caused simultaneously at least in part by the same residue, an improvement over the present level would not be possible. In any case the expression level for foreign proteins achieved so far for a WSN influenza virus carrying a set of only five amino acid substitutions (plus four most likely irrelevant changes) in its PB1 sequence, which in response to the standard pHL1104 mutant results in an expression rate 14 times above the wildtype promoter level (instead of 20 times for FPV), appears to be sufficient for its use in H1N1 influenza virus expression vectors.

The WSN-K68 virus carrying five constitutive amino acid substitutions in its PB1 polymerase subunit, which are modelled according to the FPV Bratislava sequence is a plaque-forming, stable virus strain indistinguishable from influenza virus WSN in its cell specificity and virus

yields as long as it consists only of influenza vRNA segments carrying wildtype promoter sequences. In the presence of an (additional) influenza vRNA segment carrying a promoter-up terminal sequence the corresponding viral mRNA will be synthesized at high rates and that vRNA will be amplified disproportionately causing production of defective particles due to over-abundance of that single (foreign) viral segment over all the others. As described earlier (WO 00/53789 and EP 00115626.4) this can be brought back into a balanced, stable situation via construction of bicistronic segments, carrying the foreign gene in covalent junction with one of the viral genes, either according to the ambisense or to the tandem design. In addition, a replicational balance has to be achieved between that bicistronic segment and the set of seven regular segments through variation of the overall length of the bicistronic segment and the variant promoter sequence attached to it. With regard to transcription and consequent protein expression the lower-level yield of the viral gene product has to be brought into approximate balance with other viral gene products, while the higher yielding foreign gene product expression is maintained in imbalance with regard to the viral genes.

Alternatively, influenza virus strain WSN-K68 may be used directly as a helper virus for production of unstable recombinant viral progeny, with inherent suicide properties equivalent to attenuation. A disadvantage of that scheme is the presence of progeny helper viruses besides recombinant viruses in the supernatant of plasmid DNA transfected and helpervirus infected cells.

Construction of influenza virus strain WSN-K68 (H1N1) and expectedly of similar K68 variants of H2N2 or H3N2 viruses solves the problem of biological safety; it helps to avoid the use of H7-type viral hemagglutinin-containing viral vectors and their sensitivity to ubiquitous proteases.

The respective "major" amino acid positions in the PB1 subunit of the various parental H2N2 and H3N2 viruses mentioned earlier are largely

identical to WSN, and always different from the unique sequence of FPV Bratislava (see Fig. 1), and therefore, these other viral strains are expected to become similarly converted from enhanced transcription-deficient into enhanced transcription-proficient viruses by that same operation.

The location of the two groups of apparently crucial amino acid substitutions within the PB1 sequence overlaps in one group: L628M, V644A and T741A with one of the known binding regions for the vRNA promoter sequence, and also is in the neighbourhood of the 5'vRNA cross-link site at R571/R572. The other group of exchanges in WSN-K68: D383E, S385P, and I396L is located within the region of primary (S445/D446/D447) and in particular secondary consensus sequence elements predicted to be involved in nucleotide polymerization enzymatic activity (Poch O. et al, EMBO J. Dec. 1;8(12):3867-74 (1990); Biswas S.K., Nayak D.P., J. Virol. Mar;68(3):1819-25 (1994)). Whereas only cRNA and not vRNA terminal sequence binding has been observed in that region (Gonzales S., Ortin J., EMBO J. Jul 1;18(13):3767-75 (1999)), the enzymatic reaction centre would have to be expected to get into close contact with both of its substrates, cRNA and vRNA.

No amino acid exchanges and hence no influence on PB1 or on viral polymerase promoter recognition properties is observed here for the N-terminal region of the PB1 polypeptide chain, which is known to interact with both the vRNA and cRNA promoter (1-143), and the same is true for the region of the 3'vRNA cross-link site (249-256). That result may be regarded to be disappointing, since the major effect on promoter-up variation originates from base-pair exchanges at positions 3 and 8 from the 3'-end. While it is obvious from the various results obtained previously with different methods and also including our own data, that widely separated parts of the PB1 polypeptide chain do interact, simultaneously or consecutively, with individual structural elements of the template molecules, and more specifically with both parts of the two RNA

promoter structures, the 3D structure(s) of the entire enzyme or its PB1 subunit are not yet known.

The binding studies of Gonzales S., Ortin J., EMBO J. Jul 1;18(13):3767-75 (1999) have been done *in vitro* using large deletion variants of the PB1 polypeptide chain, which might cause severe structural deformations in the protein fragments remaining, and hence yield artifactual results. The cross-linking studies by Li M.L. et al., EMBO J. Oct. 1;17(19):5844-52 (1998) used rather short 5' or 3' oligonucleotides with a single thio-uridine residue in 5' position 15 or in 3' position 10. Both positions are located in the distal promoter element which is known to be double-stranded, while only single-stranded oligonucleotides have been used in these experiments. Certainly for the distal promoter element with its double-stranded RNA structure, but most likely also for the proximal promoter element, simultaneous binding of the 5' and 3' terminal sequence sections would have been more appropriate and might have given different results. Also, in a consecutive binding reaction of first the 5' vRNA terminal sequence, and thereafter the 3' vRNA end a major conformational shift of the entire molecule has been observed (Klumpp et al., EMBO J; 16:1248-1257 (1997)). Finally, it is known that the proximal and the distal promoter elements are independent conformational units in the vRNA promoter structure, and it is the proximal element that has to be recognized in detail by polymerase, since it is the one that carries the promoter-up mutations (Flick R. et al., RNA, Oct;2(10):1046-57 (1996)). Therefore, the UV cross-linking results obtained for two nucleotide positions only in the distal element might be misleading here also for that reason. On the other hand, our *in vivo* determination of a set of amino acid positions involved in enhanced transcription proficiency versus deficiency, i.e. in recognition of single nucleotide and/or base-pair exchanges within the vRNA promoter structure (and located in full-size functional polymerase molecules) is certainly a much more gentle and more reliable way of determining polymerase functional elements than any of the *in vitro* methods used so far. The PB1 amino acids involved in

recognizing that 3'-3:8 basepair and sensing a single base-pair substitution at that location, are likely to be either in direct contact with those nucleotides or at most might be located in the subsequent chain of domain interactions within the protein leading to conformational changes and the observed response, i.e. enhanced transcription initiation rates.

According to embodiment (3) defined above and the explanations given hereinbefore, the influenza virus of the invention is suitable for high yield expression of one or more foreign or altered proteins. The foreign recombinant or altered viral gene may be present within an additional RNA segment or in a replacing segment, which comprise the foreign or altered gene encoding the protein to be expressed in monocistronic arrangement and have a modified vRNA promoter sequence as defined above (embodiment (4)), and/or within a bicistronic vRNA segment, preferably in ambisense or in tandem arrangement (embodiments (5) and (6), respectively), which includes the foreign gene encoding the protein to be expressed and has a modified vRNA promoter sequence as defined above.

Concerning embodiment (4), which relates to the expression of foreign glycoprotein genes and incorporation of those glycoproteins in the viral envelopes, it is referred to DE 197 09 512 (the disclosure thereof is herewith incorporated by reference). According to said embodiment the genes of different foreign glycoproteins of general type I, i.e., with a hydrophobic membrane anchoring sequence close to the C terminus, can be used for corresponding cDNA constructions, as designed for the expression of other genes, so that corresponding artificial vRNA molecules can be formed, i.e., in minus strand orientation. The foreign genes are inserted instead of the coding sequence of an influenza gene, flanked by authentic or slightly modified non-coding regions, as present in the influenza vRNA molecule. In addition to its own signal peptide sequence or the one borrowed from hemagglutinin (HA), the recombinant glycoprotein sequence then comprises its complete own, i.e., HA-foreign, ectodomain, followed by either its own transmembrane domain or, more frequently, that of

hemagglutinin including its C-terminal "cytoplasmic" tail sequence (for HA: 26 + 11 amino acids). The same principle of construction applies to non-glycoproteins which may be converted into artificial surface proteins by being connected with the two flanking signal peptide and membrane anchor elements derived from viral hemagglutinin.

Concerning embodiment (5) it is referred to WO 00/53789 (the disclosure thereof is herewith incorporated by reference). In the influenza virus of said embodiment preferably at least one of the regular viral RNA segments is replaced by an ambisense RNA segment which contains one of the standard viral genes in sense orientation and a foreign, recombinant gene in anti-sense orientation or vice versa in overall convergent arrangement. It is moreover preferred that in the ambisense RNA molecule said foreign recombinant gene is covalently bound to one of the viral genes while the original vRNA segment coding for the same gene is deleted from the recombinant virus by a specific ribozyme cleavage, or left out from the set of RNA-polymerase I viral cDNA clones and substituted by the corresponding ambisense RNA expressing cDNA clone in the process of direct generation of recombinant influenza viruses (see below).

The foreign gene(s) in ambisense covalent junction with the viral gene(s) preferably code for proteins and/or glycoproteins which are secreted from cells infected with the recombinant virus, such as lymphokines or extracellular enzymes, or code for glycoproteins that are incorporated into the viral envelope as well as the plasma membrane of the infected cell. In another preferred embodiment the foreign gene(s) in ambisense covalent junction with the viral gene(s) code for proteins or artificial polypeptides designed to support an efficient HLA-restricted presentation of inherent epitopes at the surface of infected cells, for stimulation of B cell and/or T cell response. Such proteins or artificial polypeptides constitute for instance a tumor antigen or an artificial oligomeric series of T cell epitopes. Finally, the foreign genetic insert(s) may be suitable for transfer and expression of RNA molecules, including antisense RNAs and ribozymes

within the infected cells. Such recombinant influenza viruses are suitable for sequence specific gene silencing, for example by RNA antisense or ribozyme RNA interference mechanisms.

A preferred virus of embodiment (5) of the invention is where in the regular viral RNA segments one or both of the standard glycoproteins hemagglutinin and neuraminidase have been exchanged into foreign glycoprotein(s), or preferably into fusion glycoproteins consisting of an anchor segment derived from hemagglutinin and an ectodomain obtained from the foreign source, viral or cellular, or in which such recombinant glycoprotein has been inserted as a third molecular species in addition to the remaining standard components.

Concerning embodiment (6) of the invention it is referred to EP 00115626.4 (the disclosure thereof is herewith incorporated by reference). In the tandem RNA segment of said embodiment, one of the standard viral genes is preferably in covalent junction with a foreign, recombinant gene and said tandem RNA segment has an upstream splice donor and a downstream splice acceptor signal surrounding the proximal coding region. "Proximal" and "proximal position" according to the present invention refers to the 5' position of one of the genes in the bicistronic viral mRNA, i.e., ahead (upstream) of the second gene in "distal position".

Expression of both gene products in the tandem constructions is made possible by way of an upstream splice donor and a downstream splice acceptor signal surrounding the proximal coding region of such a quality that splicing does occur in part of the mRNA molecules only, i.e., both mRNAs spliced and unspliced are present in the infected cell. For compensation with regard to the vRNA length the bicistronic segment is connected to a promoter variant of enhanced replication and transcription rates as defined hereinbefore.

The splice donor and the splice acceptor signals are selected from authentic sequences as present in influenza segments 7 and 8 or other partially effective splice reaction substrates, preferably those of influenza virus WSN segment 7, i.e., 5'-AG↓GTACGTTTC-3' (donor) and 5'-GCTGAAAAATGATCTTCTTGAAAATTGCAG↓GC-3' (acceptor).

In a preferred influenza virus according to embodiment (6) at least one of the regular viral RNA segments is replaced by a tandem RNA segment which contains one of the standard viral genes in distal position, and a foreign, recombinant gene in proximal position, both in anti-sense orientation, or vice-versa. It is moreover preferred that the same viral gene as present in the bicistronic RNA segment is deleted from the recombinant virus by specific ribozyme cleavage or is left out from the set of RNA-polymerase I cDNA clones and substituted by the corresponding tandem bicistronic RNA expressing cDNA clone in the direct generation of recombinant influenza viruses from plasmid DNAs (see below).

The foreign gene(s) in tandem covalent junction with the viral gene(s) preferably code for proteins and/or glycoproteins which are secreted from cells infected with the recombinant virus, such as lymphokines or extracellular enzymes, or code for glycoproteins that are incorporated into the viral envelope as well as the plasma membrane of the (abortively) infected cell. In another preferred embodiment the foreign gene(s) in tandem covalent junction with the viral gene(s) code for proteins or artificial polypeptides designed to support an efficient HLA-restricted presentation of inherent epitopes at the surface of infected cells, for stimulation of B cell and/or T cell responses. Such proteins or artificial polypeptides constitute for instance a tumor antigen or an artificial oligomeric series of T cell epitopes that have been identified within a polypeptide chain. Finally, the foreign genetic insert(s) may be suitable for expression of RNA molecules, including antisense RNAs and ribozymes, within the infected cells. Such recombinant influenza viruses are suitable

for sequence specific gene silencing, for example by RNA antisense or ribozyme interference mechanisms.

A preferred recombinant virus of embodiment (6) of the invention is where in the regular viral RNA segments one or both of the standard glycoproteins hemagglutinin and neuraminidase have been exchanged into foreign glycoproteins, or preferably into fusion glycoproteins consisting of an anchor segment derived from hemagglutinin and an ectodomain obtained from the foreign source, viral or cellular, or in which such recombinant glycoprotein has been inserted as a third molecular species in addition to the remaining standard components.

According to embodiments (5) and (6) the invention provides

- a stable recombinant influenza virus containing (up to) seven regular vRNA segments plus one (or more) additional bicistronic segment(s) coding for a foreign gene in covalent conjunction with one of the influenza genes, in ambisense or in tandem arrangement, and
- a method for the construction of stable recombinant influenza viruses through (a) bicistronic vRNA segment(s) in ambisense or in tandem arrangement, that is also applicable as a method for attenuation and for prevention of reassortment between co-infecting influenza viruses.

In a particular application of embodiment (6) the tandem bicistronic mRNA codes for one of the viral genes, such as hemagglutinin, in conjunction with (all or) part of the viral neuraminidase coding sequence or the viral NS1 coding sequence, in inverted (antisense) orientation, while the authentic neuraminidase vRNA segment or NS1 coding sequence is otherwise missing entirely in these recombinant viruses. In another variation of these constructs an anti-neuraminidase or anti-NS1 ribozyme sequence is also provided together with the (partial) neuraminidase or NS1 antisense sequence, in the proximal or in the distal position of these bicistronic recombinant segments. Recombinant viruses of this character

are propagated in culture media with addition of exogenous neuraminidase or in tissue culture cells with inactivated interferon genes, e.g., Vero cells.

The absence of a functional neuraminidase gene serves as a strong attenuation mechanism resulting in single-step infections of such recombinant viruses only. While a functional neuraminidase gene could be provided in case of another (wildtype) influenza virus superinfecting the same cell, expression of that gene is very much reduced through antisense RNA interaction and/or destruction of the corresponding vRNA through ribozyme cleavage, designed to interfere with production of infectious progeny even from co-infected cells; as a barrier against reassortment in double infected cells. The same argument applies for the NS1-deleted viruses which in addition carry an anti-NS1 vRNA antisense or ribozyme sequence, as a second feature besides carrying a foreign recombinant gene in ambisense or tandem bicistronic design.

Recombinant viral RNAs coding simultaneously for two genes in tandem organization within a construct, in which one of the viral genes is connected in covalent junction with a foreign coding sequence, are constructed via E. coli plasmid vector DNAs designed for an *in vivo* transcription of minus-strand vRNAs by cellular RNA-polymerase I. In these constructs the gene in plus-strand proximal (upstream) position is surrounded by splice signals of limited activity such that both mRNAs, spliced and unspliced are present in the infected cell. Either the foreign gene or the viral gene may be in that upstream position. In the majority of applications the higher rate of expression will be reserved for the foreign coding sequence, while the lower expression rate of the viral gene is adapted to be approximately in balance with expression of the other viral genes encoded by the regular viral segments.

To achieve such a balanced rate of expression, the splice signals and the promoter have to be chosen properly (Flick and Hobom, Interaction of influenza virus polymerase with viral RNA in the 'corkscrew' conformation,

J. Gen. Virol. 80, 2565-2572 (1999)). At an increased overall transcription rate, the resulting mRNAs shall be spliced inefficiently if the viral gene is in the distal (downstream) position. Vice-versa, if the foreign gene is in the distal position, splicing to obtain the foreign mRNA shall be achieved efficiently. Both designs serve to reach an over-expression of the foreign gene relative to its comparison viral gene, of which the expression shall be in balance with the expression of the other viral genes. Further, the promoter variant attached to the bicistronic segment has the function to compensate for the increased gene length by way of an increased replication rate.

The influenza vRNA segments preferably used for construction of bicistronic segments include the neuraminidase (No. 6), hemagglutinin (No. 4) and NS segment (No. 8). In the NS segment the foreign gene may also substitute for the NS1 gene, leaving the viral NS2 gene in its place. These recombinant viruses can, as an example, be made by the following procedure: A recombinant virus population can be selected by repeated ribozyme-mediated cleavage of a helper-virus segment carrying inserted ribozyme cleavage sites in flanking positions of the same viral gene in the monocistronic segment as has been included in the bicistronic construct (PCT/EP00/01903). By serial viral passaging and relying on the output of reporter genes in equivalently constructed bicistronic segments, a balanced mode of expression can be achieved in choosing the right set of elements: promoter variant, splice signals, plus a limited variation in segment length. The construct that gives rise to the balanced, stable expression may then be used for designing a multiple cDNA transfection procedure of helper-free generation of influenza viruses according to Hoffmann et al., Proc. Natl. Acad. Sci. USA, Vol 97, 6108-6114 (May 2000). The resulting recombinant influenza virus, obtained via single plaque in pure helper-free state, is subjected to another series of propagation steps to finally evaluate its properties.

In a particular application this design is used for establishing a controlled mode of viral attenuation. Attenuation of influenza viruses so far has been achieved in cold-sensitive mutants (Edwards et al., J. Infect. Dis. 169, 68-76(1994)), by deletion of the NS1 gene (partial attenuation, Egorov et al., J. Virol. 72, 6437-6441 (August 1998) and Palese et al., Proc. Natl. Acad. Sci USA, 4309-4314 (April 2000)), or through deletion of the neuraminidase gene (full attenuation, Kawaoka et al., J. Virol. 74, 5206-5212 (June 2000)). The latter approach is adapted here, together with a novel technique for viral attenuation, which for the first time is also able to interfere with (chance) superinfection by wild-type viruses.

In this embodiment of the invention a second bicistronic cDNA construct is designed, which instead of carrying another foreign gene is coding for part of the viral neuraminidase gene in antisense orientation, with or without being surrounded both by splice donor and acceptor elements. In another version of that design a 2 x 50 nucleotide antisense segment complementary to a region of the neuraminidase sequence has been cloned in flanking positions relative to a ribozyme construct according to the hammerhead design and oriented against a common GUC triplett within the neuraminidase sequence in a majority of current post-viral isolates. In a preferred design this antisense expression construct has been attached to the hemagglutinin vRNA segment, while another gene or reporter gene is encoded in a second bicistronic vRNA, in conjunction with NS2. The same design applies for an anti-NS1 virus, which itself does not carry an NS1 gene, and has a foreign recombinant gene in conjunction with neuraminidase vRNA or NS2 vRNA.

Propagation of recombinant viruses deleted for the neuraminidase (NA) gene requires an addition of external neuraminidase to the medium. In the absence of neuraminidase, infection by the NA deletion viruses is abortive: no infectious progeny is produced. Upon co-infection (3 + 3 per cell) of recombinant viruses together with wildtype viruses no progeny virus or plaque is observed, which is attributed to antisense-blocked expression

and/or (partial) ribozyme destruction of the neuraminidase segment originating from the wild-type virus. According to this design, the recombinant viruses described are not only attenuated in single infections, but simultaneously interfere with wildtype virus superinfection, and therefore, no re-assortment between the two viruses will occur.

Concerning the process of embodiment (8) it is referred to the disclosure of WO 96/10641, PCT/EP00/01903 and EP 00115626 referred to above (the disclosures of which are herewith incorporated by reference) and the detailed discussion of the production method set forth above.

Concerning the embodiment (9) a final step in the generation of WSN/FPV-PB1 chimeric viruses such as influenza WSN-K68 consists in performing an eight cDNA plasmid-cotransfection into 293T cells designed according to Hoffmann et al (Hoffmann E. et al., Proc. Natl. Acad. Sci. USA 97 (11), 6108-6113 (2000)), i.e., carrying inserts cloned into vector plasmid pHW2000 or an equivalently organized plasmid vector containing flanking RNA-polymerase I as well as RNA-polymerase II transcription units, in opposite direction to each other and extending across the central cDNA insert. The inserts used in a set of eight dual expression plasmids constructed accordingly consist of wildtype WSN cDNAs derived from the 7 segments except for segment 2 (PB1), which was constructed using PB1 chimeric plasmid pHL3268 as a starting material. Cotransfection with all eight plasmids after 72 hours resulted in virus containing supernatants, which can be used for plaque purification and further propagation on MDCK cells, and for characterization of the viral isolate by RT-PCR followed by restriction analysis or DNA sequencing.

Generation of recombinant influenza viruses followed the same outline, but in this case one of the WSN segments, preferably segment 6 (NA) has been exchanged for a bicistronic construct containing the NA gene in covalent junction with the foreign gene, in ambisense or in tandem design. In addition, the bicistronic segment carries promoter-up mutations in its

flanking 5' and 3' terminal sequences. Other recombinant viruses have been created using a bicistronic segment 8 (NS2/foreign) with or without an anti-NS1 ribozyme sequence inserted in a flanking position in segment 6, and still other of the segment 8 bicistronic viruses (NS2/foreign) have their segment 6 deleted entirely, with or without an anti-NA ribozyme sequence inserted in a flanking position of segment 4(HA).

The pharmaceutical composition according to embodiment (10) above and the agent of embodiments (11), (14) and (16) above (hereinafter also referred to as "medicament") contain the recombinant influenza virus in a pharmaceutically effective amount. Besides said recombinant influenza virus, the pharmaceutical composition and the medicament may contain further pharmaceutically acceptable carrier substances well-known to a person skilled in the art, such as binders, desintegrants, diluents, buffers, preservatives, etc. The pharmaceutical compositions and medicaments are solid or liquid preparations and are suitable to be administered orally, intravenously or subcutaneously. For treatment of humans a human influenza virus according to embodiments (1) to (6) is preferably used.

The pharmaceutical composition of embodiment (10) is, among others, suitable

- (i) for gene transfer into cells, preferably into mammalian cells, more preferably into human cells, by recombinant viral infection (namely via standard viral infection or employing in addition a specific attenuation mechanism);
- (ii) for gene transfer into antigen-presenting cells, preferably into dendritic cells, and the use of the obtained product for *ex vivo* immunotherapy (whereby *ex vivo* therapy is therapeutic application involving the modification of antigen-presenting cells, such as dendritic cells, wherein the modified antigen presenting cells are injected directly to the patient);
- (iii) for *in vivo* somatic gene therapy;
- (iv) for *in vivo* vaccination, including therapeutic and prophylactic vaccination;

- (v) for eliciting an immune response, including the induction of a T-cell response;
- (vi) for treating a growing tumor or a chronic infectious disease.

The pharmaceutical composition of embodiment (10) and the medicament according to embodiment (11) above is preferably suitable as a medicament against influenza and/or against other infections. The recombinant influenza virus may be present in form of inactivated preparations or may be present in form of live recombinant viruses, preferably as attenuated viruses.

Live recombinant viral vaccines, live but attenuated recombinant viral vaccines or inactivated recombinant viral vaccine can be formulated. Inactivated vaccines are "dead" in the sense that their infectivity has been destroyed. Ideally, the infectivity is destroyed without affecting its immunogenicity. For preparation of inactivated vaccines, the recombinant virus may be grown in cell cultures or in embryonated chicken eggs, purified, and inactivated by formaldehyde or β -propiolactone. The resulting vaccine is usually administered intramuscularly.

Inactivated viruses may be formulated with suitable adjuvants to enhance the immunological response. Such adjuvants include, but are not limited to, mineral gels, e.g., aluminum hydroxide, surface-active substances such as pluronic polyols, lysolecithin, peptides, oil emulsions, and potentially useful human adjuvants such as BCG.

Many methods may be used to introduce the vaccine formulations above, for example the oral, intradermal, intramuscular, intraperitoneal, subcutaneous, or intranasal routes. Where a live recombinant virus vaccine is used, it is preferred to introduce the formulation via the natural route of infection for influenza virus.

The agent according to embodiments (11), (14) and (16) above is preferably suitable for prophylactic or therapeutic vaccination, or both, against influenza and other infections. For example, recombinant viruses can be made for use in vaccines against HIV, hepatitis B virus, hepatitis C virus, herpes viruses, papilloma viruses, to name but a few. In one embodiment the recombinant virus contains the genes for surface proteins of the viruses, in another the genes for non-structural or regulatory genes. The recombinant viruses may be present in form of inactivated preparations or may be present in form of live recombinant viruses, or as live, but attenuated viruses. In an attenuated virus the recombinant virus would go through a single or at most very few propagation cycle(s) and induce a sufficient level of immune response, but would not cause disease. Such viruses lack one of the essential influenza genes or contain mutations to introduce temperature sensitivity.

The agents of embodiments (11), (14) and (16) above of the invention are applicable in *ex vivo* and *in vivo* application schemes. The RNA molecule to be expressed by means of the agent of the embodiment (14) is of an antisense sequence or double strand sequence (in ambisense bidirectional transcription) relative to a target cellular mRNA molecule. In embodiment (14) the agent is preferably suitable for sequence-specific gene silencing, preferably by RNA antisense or ribozyme interference mechanisms.

The method for the production of proteins or glycoproteins of embodiment (13) is preferably performed in tissue culture cells or in fertilized chicken eggs, in accordance with standard techniques within the general knowledge of a person skilled in the art. The proteins or glycoproteins to be expressed are those incorporated into the virus, in monocistronic or bicistronic arrangement as defined hereinbefore.

The methods according to embodiments (12), (17) and (18) of the invention include the administration of an effective amount to the mammal (i.e. the patient in need for vaccination, for influenza treatment or for

somatic gene therapy) or the administration of a sufficient infective dose of the recombinant virus to the cell system (including antigen-presenting cells, cell cultures, etc.) that is used for *ex vivo* therapy or for *in vitro* investigations, whereby the amount and dose will be determined by a person skilled in the respective arts or knowledgeable of the desired treatments. For treatment of human patients the use of human influenza viruses as defined hereinbefore is preferred.

The method of embodiment (18) is disclosed in EP 00123687.6 (which is hereby incorporated by reference). In particular, said method comprises expression of one or more tumour-associated antigens (TAA) or virus-associated antigens (VAA) by dendritic cells by

- (a) preparing a recombinant influenza virus containing a nucleotide sequence coding for the TAA or VAA, and
- (b) infecting dendritic cells with the recombinant influenza virus obtained in step (a).

The nucleotide sequence coding for the TAA or VAA may be present in the recombinant influenza virus in one of the regular segments in bicistronic arrangement or as an additional segment as explained in detail hereinbefore.

Vaccination with dendritic cells presenting tumor antigens will induce a potent primary immune response or amplify existing cytotoxic antitumor T cell responses. Therefore, tumor antigens most suitable for immunotherapy are, ideally, strictly tumor specific, or at least the immune response should have tumoral specificity. Many tumor antigens, however, are shared by tumors with normal cells and are only overexpressed in the tumor. This implies that an immune response could potentially be harmful, if an immune response to self-antigens occurs causing autoimmunity. The technology for DC vaccines shall thus result in an immune response of sufficient quality and magnitude of tumor-specific T cell responses.

Tumor-specific antigens are rare. However, a growing family of testicular antigens has been identified that are aberrantly expressed in a significant proportion of tumors of various histological types and -in addition- only in testis cells. These antigens, called cancer/testis antigens, discovered by scientists of the Ludwig Institute for Cancer Research (LICR) in Brussels and New York, and their collaborators, should ensure strict tumoral specificity of the immune responses as the germ line cells do not express MHC-I molecules.

These antigens, for example the MAGE-, GAGE- and BAGE-families, NY-ESO-I or HOM-MEL-40 (aka SSX-2) are thus prime candidates for the DC-based antitumor vaccines, when part of a potent dendritic cell vaccine based on influenza virus-mediated gene transfer. These antigens have the required selectivity for a flu-vector based DC vaccine, can most likely be readily incorporated into the recombinant virus, and are able to induce cellular immune responses. Epitope peptides derived from MAGE-A3 have been HLA-attached ("loaded") to the dendritic cells by Schuler and coworkers and the vaccine was found to induce specific CTL in patients and *in vitro*.

Furthermore, the number of tumor antigens suitable for potent therapeutic vaccines is still limited and a search for novel tumor antigens, as well as viral antigens, seems warranted. The influenza virus vector system is suitable for antigen discovery (see above). Co-expression of said antigens with LICR antigens is an important option for widening the vaccine spectrum.

In experiments it was shown that genetically modified DC, which express tumor-associated antigens can efficiently induce anti-tumour immunity and thus have a high potential as tools in cancer therapy. The gene delivery is most efficiently achieved by viral vectors. Genes encoding a melanoma derived TAA, such as MAGE-3, or the green fluorescence protein (GFP) were introduced into a high-expression avian influenza virus

vector. Monocyte-derived mature DC infected by these recombinants efficiently produced GFP or MAGE-3. More than 90 % of the infected DC can express a transduced gene. Importantly, these transduced DC retained their characteristic phenotype, their potent allogeneic T cell stimulatory capacity and were able to stimulate MAGE-3 specific CD8⁺ cytotoxic T cells. Thus influenza virus vectors provide a highly efficient gene delivery system in order to transduce human DC with TAA, which consequently stimulate TAA specific T cells.

The agent of embodiment (17) of the invention is preferably utilized to infect, transfect or transduce patient-derived immune cells. The agent is suitable for treatment of cancer or chronic viral infections. For this purpose, patient derived immune cells, preferably dendritic cells, are *ex vivo* infected with recombinant influenza viruses expressing, e.g., tumor antigens or viral antigens. The transduced cells are then reintroduced into the patient.

The preferred method for immunotherapy of embodiment (18) of the invention is an autologous immunotherapy, wherein the cells which are *ex vivo* infected are patient-derived and the transduced cells are reintroduced into the patient. The diseases to be treated by this method include cancer and chronic viral infections. For details regarding preparation of the treatment with dendritic cells see discussion of embodiment (12) above.

The method for inducing an immune response against an antigen according to embodiment (18) of the invention is suitable for inducing antibodies to foreign proteins including glycoproteins, following the administration of protein or glycoprotein antigens as part of a recombinant influenza virus in an authentic conformation, whereby the virus is purified by gentle procedures based on hemagglutination, and the gene is expressed at high rates in the infected cells. Suitable foreign genes encoding one of these antigens are polynucleotide sequences associated

with a disease, preferably an infectious disease or tumor disease, preferably the antigen is exemplified by, but not limited to,

- (i) virus-associated antigens such as the HIV antigens gp160, gp 120, rev, tat, NC, the HBV e-antigen or core antigen, the HPV E6 or E7 antigen, the herpes simplex virus glycoproteins or core proteins, other herpesvirus antigens and further viral and microbial antigens known to those skilled in the art,
- (ii) tumor associated antigens, especially the so-called cancer testis-antigens exemplified by the MAGE, BAGE and GAGE family of antigens, the NY-ESO-1 antigen, the SSX antigens, exemplified by the HOM-MEL-40.

The above polynucleotide sequences

- (i) are derivable from cDNA libraries isolated from tumor cells, or testis cells, or virus-infected cells, or microbially infected cells, or cell-lines,
- (ii) are fusion proteins with the hemagglutinin membrane anchor sequence, or polypeptides consisting of epitopes derived from one or more T-cell specific epitope sequences as present in viral or other pathogens, or in tumor associated antigens.

As influenza viruses have a wide host range, recombinant influenza viruses can be used to obtain strong immune responses in, and isolate antibodies from, a wide range of animals, including, but not limited to, fowl, pigs, horses, seals and mice. Further, influenza viruses adapted to the mouse can be used for the infection of mice by several routes including the intranasal route. This results in infection of the pharyngeal mucosal cells and results in an additional type of B cell response (e.g., as recognized in the ratio of IgG to IgA). Mice are of particular utility in the induction of immune responses in transgenic mice that have been engineered to express human antibodies. As gentle procedures based on

hemadsorption are used to purify influenza viruses, antibodies to antigens in native conformation can be isolated from the infected mammals.

The vaccines according to embodiments (19) and (21) of the invention may contain further ingredients, e.g., those set forth with regard to the pharmaceutical composition or agents set forth above.

Concerning embodiment (22) of the invention it is referred to PCT/EP00/09217, which is herewith incorporated by reference. The method of embodiment (22) is also suitable to study gene function in antigen presenting cells.

The present invention is hereinafter described in more detail by way of the following description of the figures and examples, which are, however, not to be construed so as to limit the invention.

Detailed Description of the Tables and Figures

Table 1

Viral strains	Origin of segments					pHL1844-CAT-activity	
	PB1	PB2	PA	NP	other	293T	MDCK (1)
WSN	WSN	WSN	WSN	WSN	WSN	10	<2
WF1	FPV	WSN	WSN	WSN	WSN	21	30
WF2	WSN	FPV	WSN	WSN	WSN	6	<2
WF3	WSN	WSN	FPV	WSN	WSN	8	<2
WF4	FPV	FPV	FPV	WSN	WSN	26	35
FPV	FPV	FPV	FPV	FPV	FPV	41	100

Table 1. Reassorted viral strains used as helper viruses in infection of

plasmid pHL1844 transfected 293T cells, followed by propagation of resulting recombinant progeny virus in MDCK cells.

Chloramphenicol acetyl-transferase enzymatic activities in 293T and MDCK (first viral passage) cell lysates, relative to standard FPV (=100).

Figure 1: Comparison of relevant PB1 amino acid positions in a selected set of influenza virus strains. The 22 amino acid positions divergent between FPV Bratislava (line 1) and WSN/33 (line 3) have been compared in the context of a large, representative group of viral isolates. Amino acid residues present only in WSN and in no other PB1 sequence have been underlined, while those four amino acid residues characterizing FPV Bratislava as approved to all other strains are given in bold print.

Figure 2: Chimeric structure and determination of promoter-recognition proficiency of a first set of WSN/FPV-PB1 constructs; Sections of FPV sequence within otherwise WSN-derived PB1 are indicated in heavy lining; WSN (pPolI-WSN-PB1) and FPV (pHL3115; pHL1844) are included for comparison. Upon generation of chimeric viruses in 293T cells stocks have been prepared on MDCK cells. 293T cells transfected by plasmid pHL1844 which carries the standard promoter-up variation as present originally in pHL1104 have been infected by the various viral constructs as helper viruses at m.o.i. 1 (with viral strains derived from pHL3130 and pHL3115 only at m.o.i. 0.2 and 0.5, respectively). The resulting supernatants containing the viral progeny were used for viral passage onto MDCK cells. Cell lysates from both transfected and/or infected cells were used for CAT activity measurements relative to pHL1844 recombinant FPV viruses in MDCK cells (=100), known to recognize promoter-up variant pHL1844.

A selection of functional elements within the PB1 protein sequence together with the position of six "major" amino acid substitutions have been indicated in the first line of the figure. Proposed binding regions for the vRNA (v1, v2) or the cRNA (c1, c2) promoter, and known cross-linking sites for the 5' (x5) and 3' (x3) vRNA termini are marked. P refers to the

active center of polymerase activity (PB1: 445-447). Amino acid exchanges are indicated by the WSN residue on top of the FPV residue, e.g. S/P refers to amino acid substitution S384P (WSN/FPV).

Figure 3: Chimeric structure and determination of promoter-recognition proficiency of a second, more detailed set of WSN/FPV constructs. For descriptions of experimental details, see Fig. 2.

Examples

Plasmid pHL1844: The CAT-gene containing expression plasmid pHL1844 has been designed for pseudo-vRNA synthesis by human RNA-polymerase I and carries the human rDNA core promoter region (-411 to -1) plus the murine rDNA terminator region (+ 566 to + 785 relative to the mature 28S rRNA 3'-end), both in flanking positions relative to the cDNA insert. The cDNA construct inserted in between consists of the 5' and 3' noncoding sequences as present in FPV vRNA segment 5, with the NP coding sequence itself being exchanged for the coding sequence of chloramphenicol acetyltransferase (CAT) of bacterial origin, in antisense orientation relative to RNA-polymerase I transcription. pHL1844 carries three point mutations in the 3' viral RNA promoter sequence (3'-G $\bar{3}$ A, U $\bar{5}$ C, C $\bar{8}$ U : 3'-UCAUCUUUGUCCCAU), as originally introduced into plasmid pHL1104 (Neumann G., Hobom G, J. Gen. Virol. Jul.;76(Pt 7):1709-17 (1995)).

Plasmid construction of WSN/FPV-PB1 chimera: Original plasmids WSN-PB1 (pPolI-WSN-PB1; Neumann G. et al., Proc. Natl. Acad. Sci. USA, Aug. 3;96(16):9345-50 (1999)), and FPV-PB1 as obtained by RT-PCR from FPV vRNA using PB1 terminal primer oligonucleotides that were designed for insertion into pHH21 (Hoffmann E., Justus Liebig Universität Giessen (1997)) via *Bsm*BI cleavage (Menke A. and Hobom G., unpublished) were used as starting points. Fragments have been exchanged either through restriction cleavage at homologous unique restriction sites or following PCR reactions designed to insert a "missing" restriction site in homologous

position and included within one of the primer oligonucleotides. All PCR-derived constructs have been confirmed by sequencing across the region inserted in one way or another.

Cells and viruses: Influenza viral strains A/FPV_{Bratislava} (H7/N7) and A/WSN/33 (H1/N1) as well as all viral reassortants or PB1-chimeric viral constructs were grown in Madin-Darby canine kidney (MDCK) cells. Human 293T cells were used for DNA transfection and consecutive superinfection with FPV or with the various other strains used as helper virus. The resulting recombinant influenza viruses were propagated in MDCK cells. All cell lines were grown in Dulbecco's modified Eagle's Medium (DMEM; GIBCO/BRL), supplemented with 10% fetal calf serum and antibiotics.

Generation of infectious WSN, FPV and FPV/WSN-PB1 chimeric influenza viruses: Subconfluent 293 T cells were transfected with a set of eight RNA-polymerase I plasmids yielding the eight different species of influenza vRNA molecules by *in vivo* transcription, according to Neumann et al., Proc Natl. Acad. Sci. 96, 9345-9350 (1999), together with a second set of four to five RNA-polymerase II expression plasmids for synthesis of early viral mRNA and proteins: PB1, PB2, PA, NP and (inconsistently) NS2. The latter plasmids for expression of early FPV viral proteins (pCMV-PB1, pCMV-PB2, pCMV-PA, pCMV-NP, pCMV-NS2 (A. Menke and G. Hobom, unpublished) were used in amounts of: 1 µg/1 µg/ 0.1 µg/ 1µg/ 0.3µg, respectively, while 1 µg each was used for the set of eight RNA-polymerase I vRNA plasmids. While the entire set of FPV plasmids in this category has been obtained by RT-PCR cloning into pHH21 (Menke A. and Hobom G., unpublished), the corresponding set of WSN has been obtained from G. Neumann, Madison: pPolI-WSN-PB1, pPolI-WSN-PB2, pPolI-WSN-PA, pPolI-WSN-HA, pPolI-WSN-NP, pPolI-WSN-NA, pPolI-WSN-M, pPolI-WSN-NS. Mixtures between the two series have been used for generation of WSN-FPV viral reassortants, and for generation of WSN/FPV-PB1 chimeric viruses pPolI-WSN-PB1 has been substituted by the corresponding plasmid constructs. The combined sets of plasmids have been mixed in preparation

for DNA transfection with Lipofectamin plus in a ratio of 3 µg of plasmid DNAs together with 6 µl of Lipofectamin and 8µl of Lipofectamin plus, and treated as described below. Alternatively, a set of only eight plasmids according to Hoffmann et al., Proc. Natl. Acad. Sci. 97, 6108-6113 (2000), has been used instead, again with chimeric constructs of the PB1 segment in exchange for a regular WSN-PB1 coding sequence. After 48 to 72 h the supernatant of the DNA transfected 293 T cells was used for passage on MDCK cells, and directly or thereafter also for plaque-purification and determination of the yields achieved in the generation of viral strains. Upon preparation of viral stocks the constitution in particular of PB1 vRNA as well as others was confirmed via RT-PCR analysis and diagnostic restriction cleavages of the PCR bands obtained.

pHL1844 plasmid DNA transfection and influenza virus infection: For pHL1844 DNA transfection we used $\sim 3.6 \times 10^6$ subconfluent 293T cells. Briefly: 3µg of plasmid DNA in 186µl serum-free DMEM were gently mixed with 6µl Lipofectamine and 8µl of Lipofectamine Plus (GIBCO/BRL) and incubated for 30 min at room temperature. In the meantime cells were washed with serum-free medium, and the transfection mix filled up to 3 ml with medium was carefully dispersed over the cells. After 6 h of incubation the medium was changed to DMEM containing 10% FCS and further incubated for 15 h. The transfected cells were washed very carefully with PBS+ (2.5 mM MgCl₂; 3.4 mM CaCl₂ added) and superinfected with FPV helper virus at an m.o.i. of 2-3 in 1 ml of PBS+. After 1 h the cells were washed and finally resupplied with DMEM containing 10% FCS for another 8 h of incubation. A complete replication cycle of the virus takes place in this period.

Serial passage of virus containing supernatants: After 8 h of viral propagation the supernatant containing the progeny virus was collected, and after a brief centrifugation step (10 000 rpm, 5 min) for cell debris removal it was used for passaging the recombinant virus mixture onto confluent MDCK cells as described previously (Flick R. et al. RNA,

Oct.;2(10):1046-57 (1996)).

CAT assay: Cell extracts of 110 μ l were prepared as described by Gorman *et al.* (1982). In an initial series 50 μ l of each cell lysate, and depending on the data obtained, also serially diluted amounts of the various cell lysates (always in parallel including material from one or more reference reactions) were mixed with 10 μ l of 4 mM acetyl-CoA and 8 μ l of fluorescent-labeled chloramphenicol (borondipyrromethane difluoride fluorophore: BODIPY CAM substrate, FLASH CAT kit, Stratagene). Samples were incubated at 37°C for 3 h. For extracting the reaction products 0.5 ml of ethyl acetate were added, and after a centrifugation step for 3 min at 13000 rpm the upper phase containing the acetylated products was transferred into new Eppendorf tubes and vacuum dried.

The resulting pellet was resuspended in 20 μ l ethylacetate and the reaction products were separated by thin layer chromatography (TLC plates 20/20 cm, Silica gel 60) using a solvent mixture (mobile phase) of chloroform and methanol (87:13). Finally, the reaction products were visualized by UV illumination, documented by photography and evaluated using the WinCam system (Cybertech, Berlin). Ratios of activity have been calculated relative to reference construct pHL1844 based on three independent sets of serial dilutions of cell lysates down to yielding below 30-50% of product formation in each case. The results are summarized in Table 1 and Figures 2 and 3, right hand columns.

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09. Feb. 2001

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<210> 22

<211> 5169

<212> DNA

<213> Artificial Sequence

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aaccatttga atg gat gtc aat ccg act tta ctg ttc ttg aaa gtt cct 229
      Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
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gcg caa aat gca ata agt act acg ttc cct tac act gga gat cct cca 277
Ala Gln Asn Ala Ile Ser Thr Thr Phe Pro Tyr Thr Gly Asp Pro Pro
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Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
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Thr His Gln Tyr Ser Glu Lys Gly Lys Trp Thr Thr Asn Thr Glu Thr
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Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
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gaa cca agt gga tat gca caa aca gac tgc gtc ctg gaa gca atg gct 469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala
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Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Asn Ser Cys Leu Glu
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Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly
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cgt cag act tat gat tgg act ttg aat aga aac cag cct gct gca act 613
Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr
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atg gat aag gag gaa atg gag ata aca aca cat ttc caa cga aag aga 757
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Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys
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<223> Description of Artificial Sequence: FPV-Bratislava-PB1

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35 40 45
Tyr Ser Glu Lys Gly Lys Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
50 55 60
Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
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Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
85 90 95
Glu Ser His Pro Gly Ile Phe Glu Asn Ser Cys Leu Glu Thr Met Glu
100 105 110
Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
115 120 125
Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
130 135 140
Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
145 150 155 160
Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asp Lys
165 170 175
Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
180 185 190
Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Lys
195 200 205

Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
210 215 220

Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
225 230 235 240

Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
245 250 255

Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
260 265 270

Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
275 280 285

Met Met Thr Asn Ser Gln Asp Thr Glu Leu Ser Phe Thr Ile Thr Gly
290 295 300

Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
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Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
325 330 335

Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
340 345 350

Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Leu Arg Thr Gln Ile
355 360 365

Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Glu Pro
370 375 380

Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Ile Ile Asp Gly Thr
385 390 395 400

Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
405 410 415

Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg Tyr Thr
420 425 430

Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
435 440 445

Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asp
450 455 460

Arg Phe Tyr Arg Thr Cys Lys Leu Val Gly Ile Asn Met Ser Lys Lys
465 470 475 480

Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
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Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
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Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
515 520 525

Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
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Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
545 550 555 560

Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Leu
565 570
Lys Lys Leu Trp Glu Gln Thr Arg Ser Lys Ala Gly Leu Leu Val Ser
580 585 590
Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
595 600 605
Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
610 615 620
Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile Glu Ser Val
625 630 635 640
Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys Ser Met Glu
645 650 655
Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670
Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685
Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700
Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720
Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
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aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10
gca caa aat gct ata agc aca act ttc cct tat act gga gac cct cct 277
Ala Gln Asn Ala Ile Ser Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25

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cga Arg	cag Gln	acc Thr	tat Tyr	gac Asp 130	tgg Trp	act Thr	cta Leu	aat Asn	agg Arg 135	aac Asn	cag Gln	cct Pro	gct Ala	gca Ala 140	aca Thr	613
gca Ala	ttg Leu	gcc Ala	aac Asn	aca Thr	ata Ile	gaa Glu	gtg Val	ttc Phe	aga Arg	tca Ser	aat Asn	ggc Gly	ctc Leu	acg Thr	gcc Ala	661
aat Asn	gaa Glu	tct Ser 160	gga Gly	agg Arg	ctc Leu	ata Ile	gac Asp 165	ttc Phe	ctt Leu	aag Lys	gat Asp 170	gta Val	atg Met	gag Glu	tca Ser	709
atg Met 175	aac Asn	aaa Lys	gaa Glu	gaa Glu	atg Met	gag Glu 180	atc Ile	aca Thr	act Thr	cat His	ttt Phe 185	cag Gln	aga Arg	aag Lys	aga Arg	757
cga Arg 190	gtg Val	aga Arg	gac Asp	aat Asn	atg Met 195	act Thr	aag Lys	aaa Lys	atg Met	gtg Val 200	aca Thr	cag Gln	aga Arg	aca Thr	ata Ile 205	805
ggt Gly	aaa Lys	agg Arg	aag Lys	cag Gln 210	aga Arg	ttg Leu	aac Asn	aaa Lys	agg Arg 215	agt Ser	tat Tyr	cta Leu	att Ile	agg Arg 220	gca Ala	853
tta Leu	acc Thr	ctg Leu	aac Asn 225	aca Thr	atg Met	acc Thr	aaa Lys	gat Asp 230	gct Ala	gag Glu	aga Arg	ggg Gly	aag Lys 235	cta Leu	aaa Lys	901
cgg Arg	aga Arg	gca Ala	att Ile	gca Ala	acc Thr	cca Pro	ggg Gly 245	atg Met	caa Gln	ata Ile	agg Arg	ggg Gly 250	ttt Phe	gta Val	tac Tyr	949
ttt Phe 255	gtt Val	gag Glu	aca Thr	cta Leu	gca Ala	agg Arg 260	agt Ser	ata Ile	tgt Cys	gag Glu	aaa Lys 265	ctt Leu	gaa Glu	caa Gln	tca Ser	997
gga Gly 270	ttg Leu	cca Pro	gtt Val	gga Gly	ggc Gly 275	aat Asn	gag Glu	aag Lys	aaa Lys	gca Ala 280	aag Lys	ttg Leu	gca Ala	aat Asn	gtt Val 285	1045

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Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr	
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atc act gga gat aac acc aaa tgg aac gaa aat cag aac cct cgg atg	1141
Ile Thr Gly Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met	
305 310 315	
ttt ttg gcc atg atc aca tat ata acc aga aat cag ccc gaa tgg ttc	1189
Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
320 325 330	
aga aat gtt cta agt att gct cca ata atg ttc tca aac aaa atg gcg	1237
Arg Asn Val Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala	
335 340 345	
aga ctg gga aag ggg tac atg ttt gag agc aag agt atg aaa att aga	1285
Arg Leu Gly Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg	
350 355 360 365	
act caa ata cct gca gaa atg cta gca agc atc gat ttg aaa tac ttc	1333
Thr Gln Ile Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe	
370 375 380	
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Asn Asp Ser Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile	
385 390 395	
gat ggg act gca tca ttg agc cct gga atg atg atg ggc atg ttc aat	1429
Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
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Met Leu Ser Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys	
415 420 425	
aga cac acc aag act act tac tgg tgg gat ggt ctt caa tct tct gat	1525
Arg His Thr Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp	
430 435 440 445	
gat ttt gct ctg att gtg aat gca ccc aat cat gaa ggg att caa gcc	1573
Asp Phe Ala Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala	
450 455 460	
gga gtc aac agg ttt tat cga acc tgt aag cta ctt gga att aat atg	1621
Gly Val Asn Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met	
465 470 475	
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Ser Lys Lys Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr	
480 485 490	
agc ttt ttc tat cgt tat ggg ttt gtt gcc aat ttc agc atg gag ctt	1717
Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
495 500 505	
ccc agc ttt ggg gtg tct ggg atc aac gag tct gcg gac atg agt att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
510 515 520 525	
gga gtt act gtc atc aaa aac aat atg ata aac aat gat ctt ggt cca	1813
Gly Val Thr Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro	
530 535 540	
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Ala Thr Ala Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr	
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acg tac cgg tgc cat aga ggt gac aca caa ata caa acc cga aga tca	1909
Thr Tyr Arg Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser	
560 565 570	
ttt gaa ata aag aaa ctg tgg gag caa acc cat tcc aaa gct gga ctg	1957
Phe Glu Ile Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu	
575 580 585	
ctg gtc tcc gac gga ggc cca aat tta tac aac att aga aat ctc cac	2005
Leu Val Ser Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His	
590 595 600 605	
att cct gaa gtc tgc ttg aaa tgg gaa tta atg gat gag gat tac cag	2053
Ile Pro Glu Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln	
610 615 620	
ggg cgt tta tgc aac cca ctg aac cca ttt gtc aac cat aaa gac att	2101
Gly Arg Leu Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile	
625 630 635	
gaa tca gtg aac aat gca gtg ata atg cca gca cat ggt cca gcc aaa	2149
Glu Ser Val Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys	
640 645 650	
aac atg gag tat gat gct gtt gca aca aca cac tcc tgg atc ccc aaa	2197
Asn Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys	
655 660 665	
aga aat cga tcc atc ttg aat aca agc caa aga gga ata ctt gaa gat	2245
Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp	
670 675 680 685	
gaa caa atg tac caa aag tgc tgc aac tta ttt gaa aaa ttc ttc ccc	2293
Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro	
690 695 700	
agc agt tca tac aga aga cca gtc ggg ata tcc agt atg gtg gag gct	2341
Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala	
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Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly	
720 725 730	
agg ata aag aaa gag gag ttc act gag atc atg aag atc tgt tcc acc	2437
Arg Ile Lys Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr	
735 740 745	
att gaa gag ctc aga cgg caa aaa tagtgaattt agcttgctcct tcatgaaaaa	2491
Ile Glu Glu Leu Arg Arg Gln Lys	
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atgcctggca gttccctact ctgcgatggg gagacccac actaccatcg gcgctacggc 5011
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 Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg Thr His Gln
 35 40 45
 Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
 50 55 60
 Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
 65 70 75 80
 Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
 85 90 95
 Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
 100 105 110
 Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
 115 120 125
 Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
 130 135 140
 Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
 145 150 155 160
 Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asn Lys
 165 170 175
 Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
 180 185 190
 Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Arg
 195 200 205
 Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
 210 215 220
 Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
 225 230 235 240
 Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
 245 250 255
 Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
 260 265 270

Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
 275 280 285
 Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr Ile Thr Gly
 290 295 300
 Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
 305 310 315 320
 Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
 325 330 335
 Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
 340 345 350
 Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg Thr Gln Ile
 355 360 365
 Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Asp Ser
 370 375 380
 Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile Asp Gly Thr
 385 390 395 400
 Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
 405 410 415
 Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg His Thr
 420 425 430
 Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
 435 440 445
 Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asn
 450 455 460
 Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met Ser Lys Lys
 465 470 475 480
 Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
 485 490 495
 Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
 500 505 510
 Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
 515 520 525
 Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
 530 535 540
 Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
 545 550 555 560
 Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Ile
 565 570 575
 Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu Leu Val Ser
 580 585 590
 Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
 595 600 605
 Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
 610 615 620

Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile Glu Ser Val
625 630 635 640

Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys Asn Met Glu
645 650 655

Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670

Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685

Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700

Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720

Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735

Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
740 745 750

Leu Arg Arg Gln Lys
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<211> 5169
<212> DNA
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<220>
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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180
aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10
gca caa aat gct ata agc aca act ttc cct tat act gga gac cct cct 277
Ala Gln Asn Ala Ile Ser Thr Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25
tac agc cat ggg aca gga aca gga tac acc atg gat act gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45
aca cat cag tac tca gaa agg gga aga tgg aca aca aac acc gaa act 373
Thr His Gln Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr
50 55 60
gga gca ccg caa ctc aac ccg att gat ggg cca ctg cca gaa gac aat 421
Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
65 70 75

gaa cca agt ggt tat gcc caa aca gat tgt gta ttg gaa gca atg gcc	469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala	
80 85 90	
ttc ctt gag gaa tcc cat cct ggt atc ttt gag acc tcg tgt ctt gaa	517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu	
95 100 105	
acg atg gag gtt gtt cag caa aca cga gtg gac aag ctg aca caa ggc	565
Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly	
110 115 120 125	
cga cag acc tat gac tgg act cta aat agg aac cag cct gct gca aca	613
Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr	
130 135 140	
gca ttg gcc aac aca ata gaa gtg ttc aga tca aat ggc ctc acg gcc	661
Ala Leu Ala Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala	
145 150 155	
aat gaa tct gga agg ctc ata gac ttc ctt aag gat gta atg gag tca	709
Asn Glu Ser Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser	
160 165 170	
atg aac aaa gaa gaa atg gag atc aca act cat ttt cag aga aag aga	757
Met Asn Lys Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg	
175 180 185	
cga gtg aga gac aat atg act aag aaa atg gtg aca cag aga aca ata	805
Arg Val Arg Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile	
190 195 200 205	
ggt aaa agg aag cag aga ttg aac aaa agg agt tat cta att agg gca	853
Gly Lys Arg Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala	
210 215 220	
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Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys	
225 230 235	
cgg aga gca att gca acc cca ggg atg caa ata agg ggg ttt gta tac	949
Arg Arg Ala Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr	
240 245 250	
ttt gtt gag aca cta gca agg agt ata tgt gag aaa ctt gaa caa tca	997
Phe Val Glu Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser	
255 260 265	
gga ttg cca gtt gga ggc aat gag aag aaa gca aag ttg gca aat gtt	1045
Gly Leu Pro Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val	
270 275 280 285	
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Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr	
290 295 300	
atc act gga gat aac acc aaa tgg aac gaa aat cag aac cct cgg atg	1141
Ile Thr Gly Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met	
305 310 315	
ttt ttg gcc atg atc aca tat ata acc aga aat cag ccc gaa tgg ttc	1189
Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
320 325 330	
aga aat gtt cta agt att gct cca ata atg ttc tca aac aaa atg gcg	1237
Arg Asn Val Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala	
335 340 345	

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Asn	Asp	Ser	Thr	Arg	Lys	Lys	Ile	Glu	Lys	Ile	Arg	Pro	Leu	Leu	Ile	
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			465					470					475			
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Ser	Lys	Lys	Lys	Ser	Tyr	Ile	Asn	Arg	Thr	Gly	Thr	Phe	Glu	Phe	Thr	
		480					485					490				
agc	ttt	ttc	tac	cgc	tat	gga	ttt	gta	gcc	aat	ttt	agt	atg	gag	ttg	1717
Ser	Phe	Phe	Tyr	Arg	Tyr	Gly	Phe	Val	Ala	Asn	Phe	Ser	Met	Glu	Leu	
	495					500					505					
ccc	agc	ttt	gga	gta	tca	gga	att	aat	gaa	tcg	gct	gat	atg	agc	att	1765
Pro	Ser	Phe	Gly	Val	Ser	Gly	Ile	Asn	Glu	Ser	Ala	Asp	Met	Ser	Ile	
510					515					520					525	
gga	gta	aca	gtg	ata	aag	aat	aac	atg	ata	aac	aat	gat	ctt	gga	ccg	1813
Gly	Val	Thr	Val	Ile	Lys	Asn	Asn	Met	Ile	Asn	Asn	Asp	Leu	Gly	Pro	
				530					535					540		
gca	aca	gcc	caa	atg	gct	ctc	caa	tta	ttc	atc	aag	gac	tac	aga	tat	1861
Ala	Thr	Ala	Gln	Met	Ala	Leu	Gln	Leu	Phe	Ile	Lys	Asp	Tyr	Arg	Tyr	
			545					550					555			
aca	tac	agg	tgt	cac	agg	gga	gac	aca	caa	atc	caa	acg	agg	agg	tca	1909
Thr	Tyr	Arg	Cys	His	Arg	Gly	Asp	Thr	Gln	Ile	Gln	Thr	Arg	Arg	Ser	
		560					565					570				
ttc	gag	cta	aag	aag	ctg	tgg	gag	cag	acc	cgc	tca	aag	gca	gga	ctg	1957
Phe	Glu	Leu	Lys	Lys	Leu	Trp	Glu	Gln	Thr	Arg	Ser	Lys	Ala	Gly	Leu	
	575					580					585					
ttg	gtt	tca	gat	ggc	gga	cca	aac	ctg	tac	aac	att	cgg	aat	ctc	cac	2005
Leu	Val	Ser	Asp	Gly	Gly	Pro	Asn	Leu	Tyr	Asn	Ile	Arg	Asn	Leu	His	
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Ile Pro Glu Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln	
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Gly Arg Leu Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile	
625 630 635	
gaa tct gta aac aat gct gcg gta atg cca gcc cat ggt cca gcc aaa	2149
Glu Ser Val Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys	
640 645 650	
agc atg gaa tat gat gct gtg gca act aca cac tct tgg atc cct aag	2197
Ser Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys	
655 660 665	
aga aac cgt tcc att ctc aat acg agt caa agg gga atc ctt gag gat	2245
Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp	
670 675 680 685	
gaa caa atg tac cag aag tgt tgc aac cta ttc gag aaa ttc ttc cct	2293
Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro	
690 695 700	
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Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala	
705 710 715	
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Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly	
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agg att aag aag gaa gag ttt gct gag atc atg aag atc tgt tcc acc	2437
Arg Ile Lys Lys Glu Glu Phe Ala Glu Ile Met Lys Ile Cys Ser Thr	
735 740 745	
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Ile Glu Glu Leu Arg Arg Gln Lys	
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gtttcacttc tgagttcggc atggggtcag gtgggaccac cgcgctactg ccgccaggca 5071
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tctctcatcc gccaaaacag ccaagctagc ggccgac 5169

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<211> 757
<212> PRT

<213> Artificial Sequence
<223> Description of Artificial Sequence: pHL3102

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Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg Thr His Gln
35 40 45
Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
50 55 60
Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
65 70 75 80
Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
85 90 95
Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
100 105 110
Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
115 120 125
Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
130 135 140
Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
145 150 155 160
Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asn Lys
165 170 175
Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
180 185 190
Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Arg
195 200 205
Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
210 215 220
Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
225 230 235 240
Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
245 250 255
Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
260 265 270
Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
275 280 285
Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr Ile Thr Gly
290 295 300
Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
305 310 315 320
Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
325 330 335

Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
340 345 350

Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg Thr Gln Ile
355 360 365

Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Asp Ser
370 375 380

Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile Asp Gly Thr
385 390 395 400

Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
405 410 415

Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg His Thr
420 425 430

Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
435 440 445

Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asn
450 455 460

Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met Ser Lys Lys
465 470 475 480

Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
485 490 495

Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
500 505 510

Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
515 520 525

Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
530 535 540

Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
545 550 555 560

Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Leu
565 570 575

Lys Lys Leu Trp Glu Gln Thr Arg Ser Lys Ala Gly Leu Leu Val Ser
580 585 590

Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
595 600 605

Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
610 615 620

Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile Glu Ser Val
625 630 635 640

Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys Ser Met Glu
645 650 655

Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670

Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685

Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700

Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720

Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735

Lys Glu Glu Phe Ala Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
740 745 750

Leu Arg Arg Gln Lys
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<211> 5169

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: pHL3103

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<221> CDS

<222> (191)..(2461)

<400> 28

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acaaagtgtc gcccgagta ctggctgacc tccgaagttg ggggggagcg aaagcaggca 180

aaccatttga atg gat gtc aat ccg act tta ctg ttc ttg aaa gtt cct 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10

gcg caa aat gca ata agt act acg ttc cct tac act gga gat cct cca 277
Ala Gln Asn Ala Ile Ser Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25

tac agc cat gga aca ggg aca gga tac acc atg gac aca gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45

aca cac caa tat tcg gaa aag ggg aaa tgg aca aca aac act gag act 373
Thr His Gln Tyr Ser Glu Lys Gly Lys Trp Thr Thr Asn Thr Glu Thr
50 55 60

gga gca ccc caa ctt aat cca att gat ggc cca ttg cct gag gac aat 421
Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
65 70 75

gaa cca agt gga tat gca caa aca gac tgc gtc ctg gaa gca atg gct 469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala
80 85 90

ttc ctt gaa gaa tcc cat cca gga atc ttt gaa aac tcg tgt ctt gag 517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Asn Ser Cys Leu Glu
95 100 105

acg atg gaa gtt gtt caa caa aca aga gtg gac aaa ctg acc caa ggc 565
Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly
110 115 120 125

cgt	cag	act	tat	gat	tgg	act	ttg	aat	aga	aac	cag	cct	gct	gca	act	613
Arg	Gln	Thr	Tyr	Asp	Trp	Thr	Leu	Asn	Arg	Asn	Gln	Pro	Ala	Ala	Thr	
				130					135					140		
gca	tta	gca	aac	act	ata	gag	gtc	ttt	aga	tcg	aat	ggg	cta	aca	gct	661
Ala	Leu	Ala	Asn	Thr	Ile	Glu	Val	Phe	Arg	Ser	Asn	Gly	Leu	Thr	Ala	
			145					150					155			
aat	gaa	tca	ggg	agg	ctc	ata	gat	ttc	ctc	aag	gat	gtg	atg	gaa	tca	709
Asn	Glu	Ser	Gly	Arg	Leu	Ile	Asp	Phe	Leu	Lys	Asp	Val	Met	Glu	Ser	
		160					165					170				
atg	gat	aag	gag	gaa	atg	gag	ata	aca	aca	cat	ttc	caa	cga	aag	aga	757
Met	Asp	Lys	Glu	Glu	Met	Glu	Ile	Thr	Thr	His	Phe	Gln	Arg	Lys	Arg	
	175					180					185					
aga	gta	aga	gac	aac	atg	acc	aag	aaa	atg	gtc	aca	caa	aga	aca	ata	805
Arg	Val	Arg	Asp	Asn	Met	Thr	Lys	Lys	Met	Val	Thr	Gln	Arg	Thr	Ile	
	190				195					200					205	
ggg	aag	aaa	aag	cag	aga	ctt	aac	aaa	agg	agc	tac	cta	ata	agg	gct	853
Gly	Lys	Lys	Lys	Gln	Arg	Leu	Asn	Lys	Arg	Ser	Tyr	Leu	Ile	Arg	Ala	
				210					215					220		
cta	aca	ttg	aac	aca	atg	acg	aaa	gat	gca	gaa	aga	ggg	aaa	ctg	aag	901
Leu	Thr	Leu	Asn	Thr	Met	Thr	Lys	Asp	Ala	Glu	Arg	Gly	Lys	Leu	Lys	
			225					230					235			
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Arg	Arg	Ala	Ile	Ala	Thr	Pro	Gly	Met	Gln	Ile	Arg	Gly	Phe	Val	Tyr	
		240					245					250				
ttt	gtt	gag	aca	ctg	gcg	aga	agc	att	tgc	gag	aag	ctt	gaa	cag	tct	997
Phe	Val	Glu	Thr	Leu	Ala	Arg	Ser	Ile	Cys	Glu	Lys	Leu	Glu	Gln	Ser	
	255					260					265					
ggg	cta	cca	gtt	gga	ggg	aat	gag	aag	aaa	gct	aaa	ttg	gca	aat	gtc	1045
Gly	Leu	Pro	Val	Gly	Gly	Asn	Glu	Lys	Lys	Ala	Lys	Leu	Ala	Asn	Val	
	270			275						280					285	
gtg	agg	aag	atg	atg	acg	aac	tca	caa	gac	act	gag	ctc	tct	ttc	aca	1093
Val	Arg	Lys	Met	Met	Thr	Asn	Ser	Gln	Asp	Thr	Glu	Leu	Ser	Phe	Thr	
				290					295					300		
atc	acc	gga	gac	aat	acc	aaa	tgg	aat	gag	aac	caa	aac	ccc	cga	atg	1141
Ile	Thr	Gly	Asp	Asn	Thr	Lys	Trp	Asn	Glu	Asn	Gln	Asn	Pro	Arg	Met	
			305					310					315			
ttc	ctg	gca	atg	ata	aca	tac	atc	aca	aga	aac	caa	cct	gag	tgg	ttt	1189
Phe	Leu	Ala	Met	Ile	Thr	Tyr	Ile	Thr	Arg	Asn	Gln	Pro	Glu	Trp	Phe	
		320					325					330				
aga	aat	gtc	ttg	agc	atc	gcg	ccg	ata	atg	ttt	tcg	aac	aaa	atg	gcg	1237
Arg	Asn	Val	Leu	Ser	Ile	Ala	Pro	Ile	Met	Phe	Ser	Asn	Lys	Met	Ala	
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agg	cta	ggg	aaa	ggg	tac	atg	ttc	gaa	agc	aaa	agc	atg	aag	ctc	cga	1285
Arg	Leu	Gly	Lys	Gly	Tyr	Met	Phe	Glu	Ser	Lys	Ser	Met	Lys	Leu	Arg	
	350				355					360					365	
aca	caa	ata	cca	gca	gaa	atg	cta	gca	agt	att	gat	cta	aaa	tat	ttc	1333
Thr	Gln	Ile	Pro	Ala	Glu	Met	Leu	Ala	Ser	Ile	Asp	Leu	Lys	Tyr	Phe	
				370					375					380		
aat	gaa	cca	aca	agg	aag	aaa	atc	gag	aaa	ata	agg	cct	ctc	ata	ata	1381
Asn	Glu	Pro	Thr	Arg	Lys	Lys	Ile	Glu	Lys	Ile	Arg	Pro	Leu	Ile	Ile	
			385					390					395			

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Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
400 405 410	
atg ctg agt aca gtg ttg gga gtc tca atc ctg aat ctt ggg caa aag	1477
Met Leu Ser Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys	
415 420 425	
aga tac acc aaa acc aca tac tgg tgg gat gga ctt cag tcc tct gat	1525
Arg Tyr Thr Lys Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp	
430 435 440 445	
gat ttt gct ctc atc gtg aat gca cca aat cat gag gga ata caa gcg	1573
Asp Phe Ala Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala	
450 455 460	
gga gtg gat aga ttc tac aga acc tgc aag cta gtt ggg atc aat atg	1621
Gly Val Asp Arg Phe Tyr Arg Thr Cys Lys Leu Val Gly Ile Asn Met	
465 470 475	
agc aag aaa aag tcc tat ata aat agg aca gga aca ttc gaa ttc aca	1669
Ser Lys Lys Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr	
480 485 490	
agc ttt ttc tat cgt tat ggg ttt gtt gcc aat ttc agc atg gag ctt	1717
Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
495 500 505	
ccc agc ttt ggg gtg tct ggg atc aac gag tct gcg gac atg agt att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
510 515 520 525	
gga gtt act gtc atc aaa aac aat atg ata aac aat gat ctt ggt cca	1813
Gly Val Thr Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro	
530 535 540	
gca acc gct caa atg gcc ctt cag ctg ttc atc aaa gat tac agg tac	1861
Ala Thr Ala Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr	
545 550 555	
acg tac cgg tgc cat aga ggt gac aca caa ata caa acc cga aga tca	1909
Thr Tyr Arg Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser	
560 565 570	
ttt gaa ata aag aaa ctg tgg gag caa acc cat tcc aaa gct gga ctg	1957
Phe Glu Ile Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu	
575 580 585	
ctg gtc tcc gac gga ggc cca aat tta tac aac att aga aat ctc cac	2005
Leu Val Ser Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His	
590 595 600 605	
att cct gaa gtc tgc ttg aaa tgg gaa tta atg gat gag gat tac cag	2053
Ile Pro Glu Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln	
610 615 620	
ggg cgt tta tgc aac cca ctg aac cca ttt gtc aac cat aaa gac att	2101
Gly Arg Leu Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile	
625 630 635	
gaa tca gtg aac aat gca gtg ata atg cca gca cat ggt cca gcc aaa	2149
Glu Ser Val Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys	
640 645 650	

aac atg gag tat gat gct gtt gca aca aca cac tcc tgg atc ccc aaa 2197
Asn Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys
655 660 665

aga aat cga tcc atc ttg aat aca agc caa aga gga ata ctt gaa gat 2245
Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp
670 675 680 685

gaa caa atg tac caa aag tgc tgc aac tta ttt gaa aaa ttc ttc ccc 2293
Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro
690 695 700

agc agt tca tac aga aga cca gtc ggg ata tcc agt atg gtg gag gct 2341
Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala
705 710 715

atg gtt tcc aga gcc cga att gat gca cga att gat ttc gaa tct gga 2389
Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly
720 725 730

agg ata aag aaa gag gag ttc act gag atc atg aag atc tgt tcc acc 2437
Arg Ile Lys Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr
735 740 745

att gaa gag ctc aga cgg caa aaa tagtgaattt agcttgtcct tcatgaaaaa 2491
Ile Glu Glu Leu Arg Arg Gln Lys
750 755

atgccttgtt tctactaata acccggcggc ccaaaatgcc gactcggagc gaaagatata 2551

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cacggacacc tgtcccaaaa aacgccacca tcgcagccac acacggagcg cccggggccc 2671

tctggtcaac ccaggacac acgcgggagc agcgccgggc cggggacgcc ctcccggccg 2731

cccgtgccac acgcaggggg ccggcccgtg tctccagagc gggagccgga agcattttcg 2791

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cagcagatta cgcgcagaaa aaaaggatct caagaagatc ctttgatctt ttctacgggg 3631

tctgacgctc agtggaacga aaactcacgt taagggattt tggatcatgag attatcaaaa 3691

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<211> 757

<212> PRT

<213> Artificial Sequence

<223> Description of Artificial Sequence: pHL3103

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35 40 45

Tyr Ser Glu Lys Gly Lys Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
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 Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
 65 70 75 80
 Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
 85 90 95
 Glu Ser His Pro Gly Ile Phe Glu Asn Ser Cys Leu Glu Thr Met Glu
 100 105 110
 Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
 115 120 125
 Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
 130 135 140
 Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
 145 150 155 160
 Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asp Lys
 165 170 175
 Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
 180 185 190
 Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Lys
 195 200 205
 Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
 210 215 220
 Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
 225 230 235 240
 Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
 245 250 255
 Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
 260 265 270
 Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
 275 280 285
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 290 295 300
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 305 310 315 320
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 325 330 335
 Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
 340 345 350
 Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Leu Arg Thr Gln Ile
 355 360 365
 Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Glu Pro
 370 375 380
 Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Ile Ile Asp Gly Thr
 385 390 395 400

Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
 405 410 415
 Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg Tyr Thr
 420 425 430
 Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
 435 440 445
 Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asp
 450 455 460
 Arg Phe Tyr Arg Thr Cys Lys Leu Val Gly Ile Asn Met Ser Lys Lys
 465 470 475 480
 Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
 485 490 495
 Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
 500 505 510
 Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
 515 520 525
 Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
 530 535 540
 Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
 545 550 555 560
 Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Ile
 565 570 575
 Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu Leu Val Ser
 580 585 590
 Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
 595 600 605
 Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
 610 615 620
 Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile Glu Ser Val
 625 630 635 640
 Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys Asn Met Glu
 645 650 655
 Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
 660 665 670
 Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
 675 680 685
 Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
 690 695 700
 Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
 705 710 715 720
 Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
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 Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
 740 745 750

Leu Arg Arg Gln Lys
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<211> 5169
<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: pHL3130

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<221> CDS
<222> (191)..(2461)

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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180

aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10

gca caa aat gct ata agc aca act ttc cct tat act gga gac cct cct 277
Ala Gln Asn Ala Ile Ser Thr Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25

tac agc cat ggg aca gga aca gga tac acc atg gat act gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45

aca cat cag tac tca gaa agg gga aga tgg aca aca aac acc gaa act 373
Thr His Gln Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr
50 55 60

gga gca ccg caa ctc aac ccg att gat ggg cca ctg cca gaa gac aat 421
Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
65 70 75

gaa cca agt ggt tat gcc caa aca gat tgt gta ttg gaa gca atg gcc 469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala
80 85 90

ttc ctt gag gaa tcc cat cct ggt atc ttt gag acc tcg tgt ctt gaa 517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu
95 100 105

acg atg gag gtt gtt cag caa aca cga gtg gac aag ctg aca caa ggc 565
Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly
110 115 120 125

cga cag acc tat gac tgg act cta aat agg aac cag cct gct gca aca 613
Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr
130 135 140

gca ttg gcc aac aca ata gaa gtg ttc aga tca aat ggc ctc acg gcc 661
Ala Leu Ala Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala
145 150 155

aat gaa tct gga agg ctc ata gac ttc ctt aag gat gta atg gag tca 709
Asn Glu Ser Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser
160 165 170

atg aac aaa gaa gaa atg gag atc aca act cat ttt cag aga aag aga	757
Met Asn Lys Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg	
175 180 185	
cga gtg aga gac aat atg act aag aaa atg gtg aca cag aga aca ata	805
Arg Val Arg Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile	
190 195 200 205	
ggt aaa agg aag cag aga ttg aac aaa agg agt tat cta att agg gca	853
Gly Lys Arg Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala	
210 215 220	
tta acc ctg aac aca atg acc aaa gat gct gag aga ggg aag cta aaa	901
Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys	
225 230 235	
cgg aga gca att gca aca cca ggg atg cag atc aga ggg ttt gtg tac	949
Arg Arg Ala Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr	
240 245 250	
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Phe Val Glu Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser	
255 260 265	
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Gly Leu Pro Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val	
270 275 280 285	
gtg agg aag atg atg acg aac tca caa gac act gag ctc tct ttc aca	1093
Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Leu Ser Phe Thr	
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Ile Thr Gly Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met	
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Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
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Arg Leu Gly Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Leu Arg	
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Thr Gln Ile Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe	
370 375 380	
aat gaa cca aca agg aag aaa atc gag aaa ata agg cct ctc ata ata	1381
Asn Glu Pro Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Ile Ile	
385 390 395	
gac ggc aca gcc tca tta agc ccg gga atg atg atg ggt atg ttc aac	1429
Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
400 405 410	
atg ctg agt aca gtg ttg gga gtc tca atc ctg aat ctt ggg caa aag	1477
Met Leu Ser Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys	
415 420 425	
aga tac acc aaa acc aca tac tgg tgg gat gga ctt cag tcc tct gat	1525
Arg Tyr Thr Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp	
430 435 440 445	

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Ser Lys Lys Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr	
480 485 490	
agc ttt ttc tac cgc tat gga ttt gta gcc aat ttt agt atg gag ttg	1717
Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
495 500 505	
ccc agc ttt gga gta tca gga att aat gaa tgc gct gat atg agc att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
510 515 520 525	
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Gly Val Thr Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro	
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Thr Tyr Arg Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser	
560 565 570	
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Phe Glu Leu Lys Lys Leu Trp Glu Gln Thr Arg Ser Lys Ala Gly Leu	
575 580 585	
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Leu Val Ser Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His	
590 595 600 605	
atc ccg gaa gtt tgc ctg aaa tgg gaa cta atg gat gaa gac tat cag	2053
Ile Pro Glu Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln	
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Gly Arg Leu Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile	
625 630 635	
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Glu Ser Val Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys	
640 645 650	
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Ser Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys	
655 660 665	
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Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp	
670 675 680 685	
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Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro	
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Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala
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Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly
720 725 730

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Arg Ile Lys Lys Glu Glu Phe Ala Glu Ile Met Lys Ile Cys Ser Thr
735 740 745

att gaa gag ctc aga cgg caa aaa tagtgaatth agcttgtcct tcatgaaaa 2491
Ile Glu Glu Leu Arg Arg Gln Lys
750 755

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tctgacgctc agtggaaacga aaactcacgt taagggattt tggatcatgag attatcaaaa 3691

aggatcttca cctagatcct tttaaattaa aaatgaagtt ttaaataaat ctaaagtata 3751

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<211> 757
<212> PRT
<213> Artificial Sequence
<223> Description of Artificial Sequence: pHL3130

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35 40 45
Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
50 55 60
Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
65 70 75 80
Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
85 90 95
Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
100 105 110

Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
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 Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
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85

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Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
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Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
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Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
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Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Leu
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Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile Glu Ser Val
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Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys Ser Met Glu
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Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
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Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly
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Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr
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Met Asn Lys Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg
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Tyr	Ser	Glu	Arg	Gly	Arg	Trp	Thr	Thr	Asn	Thr	Glu	Thr	Gly	Ala	Pro	50	55	60	
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Gly	Arg	Leu	Ile	Asp	Phe	Leu	Lys	Asp	Val	Met	Glu	Ser	Met	Asn	Lys	165	170	175	
Glu	Glu	Met	Glu	Ile	Thr	Thr	His	Phe	Gln	Arg	Lys	Arg	Arg	Val	Arg	180	185	190	

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Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
210 215 220

Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
225 230 235 240

Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
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Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
260 265 270

Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
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Met Met Thr Asn Ser Gln Asp Thr Glu Leu Ser Phe Thr Ile Thr Gly
290 295 300

Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
305 310 315 320

Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
325 330 335

Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
340 345 350

Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Leu Arg Thr Gln Ile
355 360 365

Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Glu Pro
370 375 380

Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Ile Ile Asp Gly Thr
385 390 395 400

Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
405 410 415

Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg Tyr Thr
420 425 430

Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
435 440 445

Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asp
450 455 460

Arg Phe Tyr Arg Thr Cys Lys Leu Val Gly Ile Asn Met Ser Lys Lys
465 470 475 480

Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
485 490 495

Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
500 505 510

Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
515 520 525

Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
530 535 540

Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
545 550 555 560
Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Ile
565 570 575
Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu Leu Val Ser
580 585 590
Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
595 600 605
Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
610 615 620
Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile Glu Ser Val
625 630 635 640
Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys Asn Met Glu
645 650 655
Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670
Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685
Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700
Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720
Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735
Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
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Leu Arg Arg Gln Lys
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<211> 5169
<212> DNA
<213> Artificial Sequence

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<221> CDS
<222> (191)..(2461)

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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180
aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10

gca Ala	caa Gln	aat Asn	gct Ala	ata Ile	agc Ser	aca Thr	act Thr	ttc Phe	cct Pro	tat Tyr	act Thr	gga Gly	gac Asp	cct Pro	cct Pro	277
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tac Tyr	agc Ser	cat His	ggg Gly	aca Thr	gga Gly	aca Thr	gga Gly	tac Tyr	acc Thr	atg Met	gat Asp	act Thr	gtc Val	aac Asn	agg Arg	325
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aca Thr	cat His	cag Gln	tac Tyr	tca Ser	gaa Glu	agg Arg	gga Gly	aga Arg	tgg Trp	aca Thr	aca Thr	aac Asn	acc Thr	gaa Glu	act Thr	373
				50					55					60		
gga Gly	gca Ala	ccg Pro	caa Gln	ctc Leu	aac Asn	ccg Pro	att Ile	gat Asp	ggg Gly	cca Pro	ctg Leu	cca Pro	gaa Glu	gac Asp	aat Asn	421
			65					70					75			
gaa Glu	cca Pro	agt Ser	ggt Gly	tat Tyr	gcc Ala	caa Gln	aca Thr	gat Asp	tgt Cys	gta Val	ttg Leu	gaa Glu	gca Ala	atg Met	gcc Ala	469
		80					85					90				
ttc Phe	ctt Leu	gag Glu	gaa Glu	tcc Ser	cat His	cct Pro	ggt Gly	atc Ile	ttt Phe	gag Glu	acc Thr	tcg Ser	tgt Cys	ctt Leu	gaa Glu	517
	95					100					105					
acg Thr	atg Met	gag Glu	gtt Val	gtt Val	cag Gln	caa Gln	aca Thr	cga Arg	gtg Val	gac Asp	aag Lys	ctg Leu	aca Thr	caa Gln	ggc Gly	565
110					115					120					125	
cga Arg	cag Gln	acc Thr	tat Tyr	gac Asp	tgg Trp	act Thr	cta Leu	aat Asn	agg Arg	aac Asn	cag Gln	cct Pro	gct Ala	gca Ala	aca Thr	613
				130					135					140		
gca Ala	ttg Leu	gcc Ala	aac Asn	aca Thr	ata Ile	gaa Glu	gtg Val	ttc Phe	aga Arg	tca Ser	aat Asn	ggc Gly	ctc Leu	acg Thr	gcc Ala	661
			145					150					155			
aat Asn	gaa Glu	tct Ser	gga Gly	agg Arg	ctc Leu	ata Ile	gac Asp	ttc Phe	ctt Leu	aag Lys	gat Asp	gta Val	atg Met	gag Glu	tca Ser	709
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atg Met	aac Asn	aaa Lys	gaa Glu	gaa Glu	atg Met	gag Glu	atc Ile	aca Thr	act Thr	cat His	ttt Phe	cag Gln	aga Arg	aag Lys	aga Arg	757
	175					180					185					
cga Arg	gtg Val	aga Arg	gac Asp	aat Asn	atg Met	act Thr	aag Lys	aaa Lys	atg Met	gtg Val	aca Thr	cag Gln	aga Arg	aca Thr	ata Ile	805
	190				195					200					205	
ggt Gly	aaa Lys	agg Arg	aag Lys	cag Gln	aga Arg	ttg Leu	aac Asn	aaa Lys	agg Arg	agt Ser	tat Tyr	cta Leu	att Ile	agg Arg	gca Ala	853
				210					215					220		
tta Leu	acc Thr	ctg Leu	aac Asn	aca Thr	atg Met	acc Thr	aaa Lys	gat Asp	gct Ala	gag Glu	aga Arg	ggg Gly	aag Lys	cta Leu	aaa Lys	901
			225					230					235			
cgg Arg	aga Arg	gca Ala	att Ile	gca Ala	acc Thr	cca Pro	ggg Gly	atg Met	caa Gln	ata Ile	agg Arg	ggg Gly	ttt Phe	gta Val	tac Tyr	949
		240					245					250				
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	255					260					265					
gga Gly	ttg Leu	cca Pro	gtt Val	gga Gly	ggc Asn	aat Glu	gag Lys	aag Lys	aaa Lys	gca Ala	aag Lys	ttg Leu	gca Ala	aat Asn	gtt Val	1045
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Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr	
290 295 300	
atc act gga gat aac acc aaa tgg aac gaa aat cag aac cct cgg atg	1141
Ile Thr Gly Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met	
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ttt ttg gcc atg atc aca tat ata acc aga aat cag ccc gaa tgg ttc	1189
Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
320 325 330	
aga aat gtt cta agt att gct cca ata atg ttc tca aac aaa atg gcg	1237
Arg Asn Val Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala	
335 340 345	
aga ctg gga aag ggg tac atg ttt gag agc aag agt atg aaa att aga	1285
Arg Leu Gly Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg	
350 355 360 365	
act caa ata cct gca gaa atg cta gca agc atc gat ttg aaa tac ttc	1333
Thr Gln Ile Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe	
370 375 380	
aat gat tca act aga aag aag att gaa aaa atc cgg ccg ctc tta ata	1381
Asn Asp Ser Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile	
385 390 395	
gat ggg act gca tca ttg agc cct gga atg atg atg ggc atg ttc aat	1429
Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
400 405 410	
atg tta agt act gta tta ggc gtc tcc atc ctg aat ctt gga caa aag	1477
Met Leu Ser Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys	
415 420 425	
aga cac acc aag act act tac tgg tgg gat ggt ctt caa tct tct gat	1525
Arg His Thr Lys Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp	
430 435 440 445	
gat ttt gct ctg att gtg aat gca ccc aat cat gaa ggg att caa gcc	1573
Asp Phe Ala Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala	
450 455 460	
gga gtc aac agg ttt tat cga acc tgt aag cta ctt gga att aat atg	1621
Gly Val Asn Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met	
465 470 475	
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Ser Lys Lys Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr	
480 485 490	
agc ttt ttc tat cgt tat ggg ttt gtt gcc aat ttc agc atg gag ctt	1717
Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
495 500 505	
ccc agc ttt ggg gtg tct ggg atc aac gag tct gcg gac atg agt att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
510 515 520 525	
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Gly Val Thr Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro	
530 535 540	

gca acc gct caa atg gcc ctt cag ctg ttc atc aaa gat tac agg tac 1861
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 545 555

acg tac cgg tgc cat aga ggt gac aca caa ata caa acc cga aga tca 1909
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 560 565 570

ttt gaa ata aag aaa ctg tgg gag caa acc cat tcc aaa gct gga ctg 1957
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 575 580 585

ctg gtc tcc gac gga ggc cca aat ttg tac aac att cgg aat ctc cac 2005
 Leu Val Ser Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His
 590 595 600 605

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 Gly Arg Leu Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile
 625 630 635

gaa tct gta aac aat gct gcg gta atg cca gcc cat ggt cca gcc aaa 2149
 Glu Ser Val Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys
 640 645 650

agc atg gaa tat gat gct gtg gca act aca cac tct tgg atc cct aag 2197
 Ser Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys
 655 660 665

aga aac cgt tcc att ctc aat acg agt caa agg gga atc ctt gag gat 2245
 Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp
 670 675 680 685

gaa caa atg tac cag aag tgt tgc aac cta ttc gag aaa ttc ttc cct 2293
 Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro
 690 695 700

agc agc tca tac aga aga cca gtt gga att tcc agt atg gtg gag gcc 2341
 Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala
 705 710 715

atg gtg tct agg gcc cgg att gat gca cga att gac ttc gag tct gga 2389
 Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly
 720 725 730

agg att aag aag gaa gag ttt gct gag atc atg aag atc tgt tcc acc 2437
 Arg Ile Lys Lys Glu Glu Phe Ala Glu Ile Met Lys Ile Cys Ser Thr
 735 740 745

att gaa gag ctc aga cgg caa aaa tagtgaattt agcttgtcct tcatgaaaa 2491
 Ile Glu Glu Leu Arg Arg Gln Lys
 750 755

atgccttgtt tctactaata acccggcggc ccaaatgcc gactcggagc gaaagatata 2551

cctcccccg ggccgggagg tcgcgtcacc gaccacgcc cgggcccagg cgacgcgcga 2611

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<211> 757

<212> PRT

<213> Artificial Sequence

<223> Description of Artificial Sequence: pHL3203

<400> 35

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Gly	Thr	Gly	Thr	Gly	Tyr	Thr	Met	Asp	Thr	Val	Asn	Arg	Thr	His	Gln
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Tyr	Ser	Glu	Arg	Gly	Arg	Trp	Thr	Thr	Asn	Thr	Glu	Thr	Gly	Ala	Pro
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Gln	Leu	Asn	Pro	Ile	Asp	Gly	Pro	Leu	Pro	Glu	Asp	Asn	Glu	Pro	Ser
	65				70					75					80
Gly	Tyr	Ala	Gln	Thr	Asp	Cys	Val	Leu	Glu	Ala	Met	Ala	Phe	Leu	Glu
			85						90					95	
Glu	Ser	His	Pro	Gly	Ile	Phe	Glu	Thr	Ser	Cys	Leu	Glu	Thr	Met	Glu
			100					105					110		
Val	Val	Gln	Gln	Thr	Arg	Val	Asp	Lys	Leu	Thr	Gln	Gly	Arg	Gln	Thr
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Tyr	Asp	Trp	Thr	Leu	Asn	Arg	Asn	Gln	Pro	Ala	Ala	Thr	Ala	Leu	Ala
	130					135					140				
Asn	Thr	Ile	Glu	Val	Phe	Arg	Ser	Asn	Gly	Leu	Thr	Ala	Asn	Glu	Ser
	145				150					155					160
Gly	Arg	Leu	Ile	Asp	Phe	Leu	Lys	Asp	Val	Met	Glu	Ser	Met	Asn	Lys
			165						170					175	
Glu	Glu	Met	Glu	Ile	Thr	Thr	His	Phe	Gln	Arg	Lys	Arg	Arg	Val	Arg
		180						185					190		
Asp	Asn	Met	Thr	Lys	Lys	Met	Val	Thr	Gln	Arg	Thr	Ile	Gly	Lys	Arg
		195					200					205			
Lys	Gln	Arg	Leu	Asn	Lys	Arg	Ser	Tyr	Leu	Ile	Arg	Ala	Leu	Thr	Leu
	210					215					220				
Asn	Thr	Met	Thr	Lys	Asp	Ala	Glu	Arg	Gly	Lys	Leu	Lys	Arg	Arg	Ala
	225				230					235					240
Ile	Ala	Thr	Pro	Gly	Met	Gln	Ile	Arg	Gly	Phe	Val	Tyr	Phe	Val	Glu
				245					250					255	

Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
 260 265 270
 Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
 275 280 285
 Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr Ile Thr Gly
 290 295 300
 Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
 305 310 315 320
 Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
 325 330 335
 Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
 340 345 350
 Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg Thr Gln Ile
 355 360 365
 Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Asp Ser
 370 375 380
 Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile Asp Gly Thr
 385 390 395 400
 Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
 405 410 415
 Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg His Thr
 420 425 430
 Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
 435 440 445
 Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asn
 450 455 460
 Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met Ser Lys Lys
 465 470 475 480
 Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
 485 490 495
 Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
 500 505 510
 Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
 515 520 525
 Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
 530 535 540
 Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
 545 550 555 560
 Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Ile
 565 570 575
 Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu Leu Val Ser
 580 585 590
 Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
 595 600 605

Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
610 615 620

Cys Asn Pro Met Asn Pro Phe Val Ser His Lys Glu Ile Glu Ser Val
625 630 635 640

Asn Asn Ala Ala Val Met Pro Ala His Gly Pro Ala Lys Ser Met Glu
645 650 655

Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670

Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685

Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700

Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720

Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735

Lys Glu Glu Phe Ala Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
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Leu Arg Arg Gln Lys
755

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<211> 5169
<212> DNA
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<220>
<223> Description of Artificial Sequence: pHL3204

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<221> CDS
<222> (191)..(2461)

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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180
aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10
gca caa aat gct ata agc aca act ttc cct tat act gga gac cct cct 277
Ala Gln Asn Ala Ile Ser Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25
tac agc cat ggg aca gga aca gga tac acc atg gat act gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45
aca cat cag tac tca gaa agg gga aga tgg aca aca aac acc gaa act 373
Thr His Gln Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr
50 55 60

100

gga gca ccg caa ctc aac ccg att gat ggg cca ctg cca gaa gac aat	421
Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn	
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gaa cca agt ggt tat gcc caa aca gat tgt gta ttg gaa gca atg gcc	469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala	
80 85 90	
ttc ctt gag gaa tcc cat cct ggt atc ttt gag acc tcg tgt ctt gaa	517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu	
95 100 105	
acg atg gag gtt gtt cag caa aca cga gtg gac aag ctg aca caa ggc	565
Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly	
110 115 120 125	
cga cag acc tat gac tgg act cta aat agg aac cag cct gct gca aca	613
Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr	
130 135 140	
gca ttg gcc aac aca ata gaa gtg ttc aga tca aat ggc ctc acg gcc	661
Ala Leu Ala Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala	
145 150 155	
aat gaa tct gga agg ctc ata gac ttc ctt aag gat gta atg gag tca	709
Asn Glu Ser Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser	
160 165 170	
atg aac aaa gaa gaa atg gag atc aca act cat ttt cag aga aag aga	757
Met Asn Lys Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg	
175 180 185	
cga gtg aga gac aat atg act aag aaa atg gtg aca cag aga aca ata	805
Arg Val Arg Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile	
190 195 200 205	
ggt aaa agg aag cag aga ttg aac aaa agg agt tat cta att agg gca	853
Gly Lys Arg Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala	
210 215 220	
tta acc ctg aac aca atg acc aaa gat gct gag aga ggg aag cta aaa	901
Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys	
225 230 235	
cgg aga gca att gca acc cca ggg atg caa ata agg ggg ttt gta tac	949
Arg Arg Ala Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr	
240 245 250	
ttt gtt gag aca cta gca agg agt ata tgt gag aaa ctt gaa caa tca	997
Phe Val Glu Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser	
255 260 265	
gga ttg cca gtt gga ggc aat gag aag aaa gca aag ttg gca aat gtt	1045
Gly Leu Pro Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val	
270 275 280 285	
gta agg aag atg atg acc aat tct cag gac act gaa att tct ttc acc	1093
Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr	
290 295 300	
atc act gga gat aac acc aaa tgg aac gaa aat cag aac cct cgg atg	1141
Ile Thr Gly Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met	
305 310 315	
ttt ttg gcc atg atc aca tat ata acc aga aat cag ccc gaa tgg ttc	1189
Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
320 325 330	

aga aat gtt cta agt att gct cca ata atg ttc tca aac aaa atg gcg	1237
Arg Asn Val Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala	
335 340 345	
aga ctg gga aag ggg tac atg ttt gag agc aag agt atg aaa att aga	1285
Arg Leu Gly Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg	
350 355 360 365	
act caa ata cct gca gaa atg cta gca agc atc gat ttg aaa tac ttc	1333
Thr Gln Ile Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe	
370 375 380	
aat gat tca act aga aag aag att gaa aaa atc cgg ccg ctc tta ata	1381
Asn Asp Ser Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile	
385 390 395	
gat ggg act gca tca ttg agc cct gga atg atg atg ggc atg ttc aat	1429
Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
400 405 410	
atg tta agt act gta tta ggc gtc tcc atc ctg aat ctt gga caa aag	1477
Met Leu Ser Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys	
415 420 425	
aga cac acc aag act act tac tgg tgg gat ggt ctt caa tct tct gat	1525
Arg His Thr Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp	
430 435 440 445	
gat ttt gct ctg att gtg aat gca ccc aat cat gaa ggg att caa gcc	1573
Asp Phe Ala Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala	
450 455 460	
gga gtc aac agg ttt tat cga acc tgt aag cta ctt gga att aat atg	1621
Gly Val Asn Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met	
465 470 475	
agc aag aaa aag tct tac ata aac aga aca ggt aca ttt gaa ttc aca	1669
Ser Lys Lys Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr	
480 485 490	
agc ttt ttc tac cgc tat gga ttt gta gcc aat ttt agt atg gag ttg	1717
Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
495 500 505	
ccc agc ttt gga gta tca gga att aat gaa tcg gct gat atg agc att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
510 515 520 525	
gga gta aca gtg ata aag aat aac atg ata aac aat gat ctt gga ccg	1813
Gly Val Thr Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro	
530 535 540	
gca aca gcc caa atg gct ctc caa tta ttc atc aag gac tac aga tat	1861
Ala Thr Ala Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr	
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aca tac agg tgt cac agg gga gac aca caa atc caa acg agg agg tca	1909
Thr Tyr Arg Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser	
560 565 570	
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575 580 585	

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Leu Val Ser Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His
590 595 600 605

att cct gaa gtc tgc ttg aaa tgg gaa tta atg gat gag gat tac cag 2053
Ile Pro Glu Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln
610 615 620

ggg cgt tta tgc aac cca ctg aac cca ttt gtc aac cat aaa gac att 2101
Gly Arg Leu Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile
625 630 635

gaa tca gtg aac aat gca gtg ata atg cca gca cat ggt cca gcc aaa 2149
Glu Ser Val Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys
640 645 650

aac atg gag tat gat gct gtt gca aca aca cac tcc tgg atc ccc aaa 2197
Asn Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys
655 660 665

aga aat cga tcc atc ttg aat aca agc caa aga gga ata ctt gaa gat 2245
Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp
670 675 680 685

gaa caa atg tac caa aag tgc tgc aac tta ttt gaa aaa ttc ttc ccc 2293
Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro
690 695 700

agc agt tca tac aga aga cca gtc ggg ata tcc agt atg gtg gag gct 2341
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705 710 715

atg gtt tcc aga gcc cga att gat gca cga att gat ttc gaa tct gga 2389
Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly
720 725 730

agg ata aag aaa gag gag ttc act gag atc atg aag atc tgt tcc acc 2437
Arg Ile Lys Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr
735 740 745

att gaa gag ctc aga cgg caa aaa tagtgaattt agcttgctct tcatgaaaaa 2491
Ile Glu Glu Leu Arg Arg Gln Lys
750 755

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cctccccgg ggccgggagg tcgcgtcacc gaccacgcc cgggcccagg cgacgcgcga 2611

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cgacaaacaa cagataaaac gaaaggccca gtctttcgac tgagcctttc gttttatttg 4951
atgcctggca gttccctact ctgcgatggg gagaccccac actaccatcg gcgctacggc 5011
gtttcacttc tgagttcggc atggggtcag gtgggaccac cgcgctactg ccgccaggca 5071
aattctgttt tatcagaccg cttctgcgtt ctgatttaat ctgtatcagg ctgaaaatct 5131
tctctcatcc gccaaaacag ccaagctagc ggccgatc 5169

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 <211> 757
 <212> PRT
 <213> Artificial Sequence
 <223> Description of Artificial Sequence: pHL3204

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 Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg Thr His Gln
 35 40 45
 Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
 50 55 60
 Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
 65 70 75 80
 Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
 85 90 95
 Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
 100 105 110
 Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
 115 120 125
 Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
 130 135 140
 Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
 145 150 155 160
 Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asn Lys
 165 170 175
 Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
 180 185 190
 Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Arg
 195 200 205
 Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
 210 215 220
 Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
 225 230 235 240
 Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
 245 250 255
 Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
 260 265 270
 Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
 275 280 285
 Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr Ile Thr Gly
 290 295 300
 Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
 305 310 315 320

Met	Ile	Thr	Tyr	Ile	Thr	Arg	Asn	Gln	Pro	Glu	Trp	Phe	Arg	Asn	Val
				325					330					335	
Leu	Ser	Ile	Ala	Pro	Ile	Met	Phe	Ser	Asn	Lys	Met	Ala	Arg	Leu	Gly
			340					345					350		
Lys	Gly	Tyr	Met	Phe	Glu	Ser	Lys	Ser	Met	Lys	Ile	Arg	Thr	Gln	Ile
		355					360					365			
Pro	Ala	Glu	Met	Leu	Ala	Ser	Ile	Asp	Leu	Lys	Tyr	Phe	Asn	Asp	Ser
	370					375					380				
Thr	Arg	Lys	Lys	Ile	Glu	Lys	Ile	Arg	Pro	Leu	Leu	Ile	Asp	Gly	Thr
385					390					395					400
Ala	Ser	Leu	Ser	Pro	Gly	Met	Met	Met	Gly	Met	Phe	Asn	Met	Leu	Ser
				405					410					415	
Thr	Val	Leu	Gly	Val	Ser	Ile	Leu	Asn	Leu	Gly	Gln	Lys	Arg	His	Thr
			420					425					430		
Lys	Thr	Thr	Tyr	Trp	Trp	Asp	Gly	Leu	Gln	Ser	Ser	Asp	Asp	Phe	Ala
		435					440					445			
Leu	Ile	Val	Asn	Ala	Pro	Asn	His	Glu	Gly	Ile	Gln	Ala	Gly	Val	Asn
	450					455					460				
Arg	Phe	Tyr	Arg	Thr	Cys	Lys	Leu	Leu	Gly	Ile	Asn	Met	Ser	Lys	Lys
465					470					475					480
Lys	Ser	Tyr	Ile	Asn	Arg	Thr	Gly	Thr	Phe	Glu	Phe	Thr	Ser	Phe	Phe
				485					490					495	
Tyr	Arg	Tyr	Gly	Phe	Val	Ala	Asn	Phe	Ser	Met	Glu	Leu	Pro	Ser	Phe
			500					505					510		
Gly	Val	Ser	Gly	Ile	Asn	Glu	Ser	Ala	Asp	Met	Ser	Ile	Gly	Val	Thr
		515					520					525			
Val	Ile	Lys	Asn	Asn	Met	Ile	Asn	Asn	Asp	Leu	Gly	Pro	Ala	Thr	Ala
	530					535					540				
Gln	Met	Ala	Leu	Gln	Leu	Phe	Ile	Lys	Asp	Tyr	Arg	Tyr	Thr	Tyr	Arg
545					550					555					560
Cys	His	Arg	Gly	Asp	Thr	Gln	Ile	Gln	Thr	Arg	Arg	Ser	Phe	Glu	Leu
				565					570					575	
Lys	Lys	Leu	Trp	Glu	Gln	Thr	Arg	Ser	Lys	Ala	Gly	Leu	Leu	Val	Ser
			580					585					590		
Asp	Gly	Gly	Pro	Asn	Leu	Tyr	Asn	Ile	Arg	Asn	Leu	His	Ile	Pro	Glu
		595					600					605			
Val	Cys	Leu	Lys	Trp	Glu	Leu	Met	Asp	Glu	Asp	Tyr	Gln	Gly	Arg	Leu
	610					615					620				
Cys	Asn	Pro	Leu	Asn	Pro	Phe	Val	Asn	His	Lys	Asp	Ile	Glu	Ser	Val
625					630					635					640
Asn	Asn	Ala	Val	Ile	Met	Pro	Ala	His	Gly	Pro	Ala	Lys	Asn	Met	Glu
				645					650					655	
Tyr	Asp	Ala	Val	Ala	Thr	Thr	His	Ser	Trp	Ile	Pro	Lys	Arg	Asn	Arg
			660					665					670		

Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685
Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700
Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720
Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735
Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
740 745 750
Leu Arg Arg Gln Lys
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<210> 38
<211> 5169
<212> DNA
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<220>
<223> Description of Artificial Sequence: pHL3246

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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180
aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10
gca caa aat gct ata agc aca act ttc cct tat act gga gac cct cct 277
Ala Gln Asn Ala Ile Ser Thr Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25
tac agc cat ggg aca gga aca gga tac acc atg gat act gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45
aca cat cag tac tca gaa agg gga aga tgg aca aca aac acc gaa act 373
Thr His Gln Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr
50 55 60
gga gca ccg caa ctc aac ccg att gat ggg cca ctg cca gaa gac aat 421
Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
65 70 75
gaa cca agt ggt tat gcc caa aca gat tgt gta ttg gaa gca atg gcc 469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala
80 85 90
ttc ctt gag gaa tcc cat cct ggt atc ttt gag acc tcg tgt ctt gaa 517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu
95 100 105

acg atg gag gtt gtt cag caa aca cga gtg gac aag ctg aca caa ggc Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly 110 115 120 125	565
cga cag acc tat gac tgg act cta aat agg aac cag cct gct gca aca Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr 130 135 140	613
gca ttg gcc aac aca ata gaa gtg ttc aga tca aat ggc ctc acg gcc Ala Leu Ala Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala 145 150 155	661
aat gaa tct gga agg ctc ata gac ttc ctt aag gat gta atg gag tca Asn Glu Ser Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser 160 165 170	709
atg aac aaa gaa gaa atg gag atc aca act cat ttt cag aga aag aga Met Asn Lys Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg 175 180 185	757
cga gtg aga gac aat atg act aag aaa atg gtg aca cag aga aca ata Arg Val Arg Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile 190 195 200 205	805
ggt aaa agg aag cag aga ttg aac aaa agg agt tat cta att agg gca Gly Lys Arg Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala 210 215 220	853
tta acc ctg aac aca atg acc aaa gat gct gag aga ggg aag cta aaa Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys 225 230 235	901
cgg aga gca att gca aca cca ggg atg cag atc aga ggg ttt gtg tac Arg Arg Ala Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr 240 245 250	949
ttt gtt gag aca ctg gcg aga agc att tgc gag aag ctt gaa cag tct Phe Val Glu Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser 255 260 265	997
ggg cta cca gtt gga ggg aat gag aag aaa gct aaa ttg gca aat gtc Gly Leu Pro Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val 270 275 280 285	1045
gtg agg aag atg atg acg aac tca caa gac act gag ctc tct ttc aca Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Leu Ser Phe Thr 290 295 300	1093
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aga aat gtc ttg agc atc gcg ccg ata atg ttt tcg aac aaa atg gcg Arg Asn Val Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala 335 340 345	1237
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Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
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atg tta agt act gta tta ggc gtc tcc atc ctg aat ctt gga caa aag	1477
Met Leu Ser Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys	
415 420 425	
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Asp Phe Ala Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala	
450 455 460	
gga gtc aac agg ttt tat cga acc tgt aag cta ctt gga att aat atg	1621
Gly Val Asn Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met	
465 470 475	
agc aag aaa aag tct tac ata aac aga aca ggt aca ttt gaa ttc aca	1669
Ser Lys Lys Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr	
480 485 490	
agc ttt ttc tat cgt tat ggg ttt gtt gcc aat ttc agc atg gag ctt	1717
Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
495 500 505	
ccc agc ttt ggg gtg tct ggg atc aac gag tct gcg gac atg agt att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
510 515 520 525	
gga gtt act gtc atc aaa aac aat atg ata aac aat gat ctt ggt cca	1813
Gly Val Thr Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro	
530 535 540	
gca acc gct caa atg gcc ctt cag ctg ttc atc aaa gat tac agg tac	1861
Ala Thr Ala Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr	
545 550 555	
acg tac cgg tgc cat aga ggt gac aca caa ata caa acc cga aga tca	1909
Thr Tyr Arg Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser	
560 565 570	
ttt gaa ata aag aaa ctg tgg gag caa acc cat tcc aaa gct gga ctg	1957
Phe Glu Ile Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu	
575 580 585	
ctg gtc tcc gac gga ggc cca aat tta tac aac att aga aat ctc cac	2005
Leu Val Ser Asp Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His	
590 595 600 605	
att cct gaa gtc tgc ttg aaa tgg gaa tta atg gat gag gat tac cag	2053
Ile Pro Glu Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln	
610 615 620	
ggg cgt tta tgc aac cca ctg aac cca ttt gtc aac cat aaa gac att	2101
Gly Arg Leu Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile	
625 630 635	

gaa tca gtg aac aat gca gtg ata atg cca gca cat ggt cca gcc aaa 2149
Glu Ser Val Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys
640 645 650

aac atg gag tat gat gct gtt gca aca aca cac tcc tgg atc ccc aaa 2197
Asn Met Glu Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys
655 660 665

aga aat cga tcc atc ttg aat aca agc caa aga gga ata ctt gaa gat 2245
Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp
670 675 680 685

gaa caa atg tac caa aag tgc tgc aac tta ttt gaa aaa ttc ttc ccc 2293
Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro
690 695 700

agc agt tca tac aga aga cca gtc ggg ata tcc agt atg gtg gag gct 2341
Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala
705 710 715

atg gtt tcc aga gcc cga att gat gca cga att gat ttc gaa tct gga 2389
Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly
720 725 730

agg ata aag aaa gag gag ttc act gag atc atg aag atc tgt tcc acc 2437
Arg Ile Lys Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr
735 740 745

att gaa gag ctc aga cgg caa aaa tagtgaatgt agcttgctct tcatgaaaaa 2491
Ile Glu Glu Leu Arg Arg Gln Lys
750 755

atgccttggt tctactaata acccgggcggc ccaaaatgcc gactcggagc gaaagatata 2551

cctcccccg ggccgggagg tcgcgtcacc gaccacgccg ccggcccagg cgacgcgcga 2611

cacggacacc tgtccccaaa aacgccacca tcgcagccac acacggagcg cccggggccc 2671

tctggtcaac ccaggacac acgcgggagc agcgcggggc cggggagcgc ctcccggccg 2731

cccggtgccac acgcaggggg ccggcccgtg tctccagagc gggagccgga agcattttcg 2791

gccggcccct cctacgaccg ggacacacga gggaccgaag gccggccagg cgcgacctct 2851

cgggcccgcac gcgcgctcag ggagcgctct ccgactccgc acgggggactc gccagaaagg 2911

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cagcaaaagg ccaggaaccg taaaaaggcc gcgttgctgg cgtttttcca taggctccgc 3031

ccccctgacg agcatcacia aaatcgacgc tcaagtcaga ggtggcgaaa cccgacagga 3091

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agaaggacag tatttggtat ctgcgctctg ctgaagccag ttaccttcgg aaaaagagtt 3511

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tctgacgctc agtggaacga aaactcacgt taagggattt tggatcatgag attatcaaaa 3691
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gcaaaaaagg gaataagggc gacacggaaa tgttgaatac tcatactctt cttttttcaa 4651
tattattgaa gcatttatca gggttattgt ctcagtgcgc gatacatatt tgaatgtatt 4711
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cgacaaacaa cagataaaac gaaaggccca gtctttcgac tgagcctttc gttttatttg 4951
atgcctggca gttccctact ctgcgatggg gagacccac actaccatcg gcgctacggc 5011
gtttcacttc tgagttcggc atggggtcag gtgggaccac cgcgctactg ccgccaggca 5071
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tctctcatcc gccaaaacag ccaagctagc ggccgatc 5169

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<212> PRT
<213> Artificial Sequence
<223> Description of Artificial Sequence: pHL3246

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111

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 Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg Thr His Gln
 35 40 45
 Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
 50 55 60
 Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
 65 70 75 80
 Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
 85 90 95
 Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
 100 105 110
 Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
 115 120 125
 Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr Ala Leu Ala
 130 135 140
 Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
 145 150 155 160
 Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asn Lys
 165 170 175
 Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
 180 185 190
 Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Arg
 195 200 205
 Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
 210 215 220
 Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
 225 230 235 240
 Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
 245 250 255
 Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
 260 265 270
 Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
 275 280 285
 Met Met Thr Asn Ser Gln Asp Thr Glu Leu Ser Phe Thr Ile Thr Gly
 290 295 300
 Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
 305 310 315 320
 Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
 325 330 335
 Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
 340 345 350
 Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Leu Arg Thr Gln Ile
 355 360 365

Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Asp Ser
 370 375 380
 Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile Asp Gly Thr
 385 390 395 400
 Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
 405 410 415
 Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg His Thr
 420 425 430
 Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
 435 440 445
 Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asn
 450 455 460
 Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met Ser Lys Lys
 465 470 475 480
 Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
 485 490 495
 Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
 500 505 510
 Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
 515 520 525
 Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
 530 535 540
 Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
 545 550 555 560
 Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Ile
 565 570 575
 Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu Leu Val Ser
 580 585 590
 Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
 595 600 605
 Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
 610 615 620
 Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile Glu Ser Val
 625 630 635 640
 Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys Asn Met Glu
 645 650 655
 Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
 660 665 670
 Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
 675 680 685
 Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
 690 695 700
 Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
 705 710 715 720

Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735
Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
740 745 750
Leu Arg Arg Gln Lys
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<212> DNA
<213> Artificial Sequence

<220>
<223> Description of Artificial Sequence: pHL3247

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<221> CDS
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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180
aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
1 5 10
gca caa aat gct ata agc aca act ttc cct tat act gga gac cct cct 277
Ala Gln Asn Ala Ile Ser Thr Phe Pro Tyr Thr Gly Asp Pro Pro
15 20 25
tac agc cat ggg aca gga aca gga tac acc atg gat act gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45
aca cat cag tac tca gaa agg gga aga tgg aca aca aac acc gaa act 373
Thr His Gln Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr
50 55 60
gga gca ccg caa ctc aac ccg att gat ggg cca ctg cca gaa gac aat 421
Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
65 70 75
gaa cca agt ggt tat gcc caa aca gat tgt gta ttg gaa gca atg gcc 469
Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala
80 85 90
ttc ctt gag gaa tcc cat cct ggt atc ttt gag acc tcg tgt ctt gaa 517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu
95 100 105
acg atg gag gtt gtt cag caa aca cga gtg gac aag ctg aca caa ggc 565
Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly
110 115 120 125
cga cag acc tat gac tgg act cta aat agg aac cag cct gct gca aca 613
Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr
130 135 140

gca ttg gcc aac aca ata gaa gtg ttc aga tca aat ggc ctc acg gcc	661
Ala Leu Ala Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala	
145 150 155	
aat gaa tct gga agg ctc ata gac ttc ctt aag gat gta atg gag tca	709
Asn Glu Ser Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser	
160 165 170	
atg aac aaa gaa gaa atg gag atc aca act cat ttt cag aga aag aga	757
Met Asn Lys Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg	
175 180 185	
cga gtg aga gac aat atg act aag aaa atg gtg aca cag aga aca ata	805
Arg Val Arg Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile	
190 195 200 205	
ggt aaa agg aag cag aga ttg aac aaa agg agt tat cta att agg gca	853
Gly Lys Arg Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala	
210 215 220	
tta acc ctg aac aca atg acc aaa gat gct gag aga ggg aag cta aaa	901
Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys	
225 230 235	
cgg aga gca att gca acc cca ggg atg caa ata agg ggg ttt gta tac	949
Arg Arg Ala Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr	
240 245 250	
ttt gtt gag aca cta gca agg agt ata tgt gag aaa ctt gaa caa tca	997
Phe Val Glu Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser	
255 260 265	
gga ttg cca gtt gga ggc aat gag aag aaa gca aag ttg gca aat gtt	1045
Gly Leu Pro Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val	
270 275 280 285	
gta agg aag atg atg acc aat tct cag gac act gaa att tct ttc acc	1093
Val Arg Lys Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr	
290 295 300	
atc act gga gat aac acc aaa tgg aac gaa aat cag aac cct cgg atg	1141
Ile Thr Gly Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met	
305 310 315	
ttt ttg gcc atg atc aca tat ata acc aga aat cag ccc gaa tgg ttc	1189
Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
320 325 330	
aga aat gtt cta agt att gct cca ata atg ttc tca aac aaa atg gcg	1237
Arg Asn Val Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala	
335 340 345	
aga ctg gga aag ggg tac atg ttt gag agc aag agt atg aaa att aga	1285
Arg Leu Gly Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg	
350 355 360 365	
act caa ata cct gca gaa atg cta gca agt att gat cta aaa tat ttc	1333
Thr Gln Ile Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe	
370 375 380	
aat gaa cca aca agg aag aaa atc gag aaa ata agg cct ctc ata ata	1381
Asn Glu Pro Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Ile Ile	
385 390 395	
gac ggc aca gcc tca tta agc ccg gga atg atg atg ggt atg ttc aac	1429
Asp Gly Thr Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn	
400 405 410	

115

atg	ctg	agt	aca	gtg	ttg	gga	gtc	tca	atc	ctg	aat	ctt	ggg	caa	aag	1477
Met	Leu	Ser	Thr	Val	Leu	Gly	Val	Ser	Ile	Leu	Asn	Leu	Gly	Gln	Lys	
	415					420					425					
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Arg	Tyr	Thr	Lys	Thr	Thr	Tyr	Trp	Trp	Asp	Gly	Leu	Gln	Ser	Ser	Asp	
430					435					440					445	
gat	ttt	gct	ctc	atc	gtg	aat	gca	cca	aat	cat	gag	gga	ata	caa	gcg	1573
Asp	Phe	Ala	Leu	Ile	Val	Asn	Ala	Pro	Asn	His	Glu	Gly	Ile	Gln	Ala	
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Gly	Val	Asp	Arg	Phe	Tyr	Arg	Thr	Cys	Lys	Leu	Val	Gly	Ile	Asn	Met	
		465						470					475			
agc	aag	aaa	aag	tcc	tat	ata	aat	agg	aca	gga	aca	ttc	gaa	ttc	aca	1669
Ser	Lys	Lys	Lys	Ser	Tyr	Ile	Asn	Arg	Thr	Gly	Thr	Phe	Glu	Phe	Thr	
	480						485					490				
agc	ttt	ttc	tat	cgt	tat	ggg	ttt	gtt	gcc	aat	ttc	agc	atg	gag	ctt	1717
Ser	Phe	Phe	Tyr	Arg	Tyr	Gly	Phe	Val	Ala	Asn	Phe	Ser	Met	Glu	Leu	
	495					500					505					
ccc	agc	ttt	ggg	gtg	tct	ggg	atc	aac	gag	tct	gcg	gac	atg	agt	att	1765
Pro	Ser	Phe	Gly	Val	Ser	Gly	Ile	Asn	Glu	Ser	Ala	Asp	Met	Ser	Ile	
510					515					520					525	
gga	gtt	act	gtc	atc	aaa	aac	aat	atg	ata	aac	aat	gat	ctt	ggt	cca	1813
Gly	Val	Thr	Val	Ile	Lys	Asn	Asn	Met	Ile	Asn	Asn	Asp	Leu	Gly	Pro	
				530					535					540		
gca	acc	gct	caa	atg	gcc	ctt	cag	ctg	ttc	atc	aaa	gat	tac	agg	tac	1861
Ala	Thr	Ala	Gln	Met	Ala	Leu	Gln	Leu	Phe	Ile	Lys	Asp	Tyr	Arg	Tyr	
			545					550					555			
acg	tac	cgg	tgc	cat	aga	ggt	gac	aca	caa	ata	caa	acc	cga	aga	tca	1909
Thr	Tyr	Arg	Cys	His	Arg	Gly	Asp	Thr	Gln	Ile	Gln	Thr	Arg	Arg	Ser	
		560					565					570				
ttt	gaa	ata	aag	aaa	ctg	tgg	gag	caa	acc	cat	tcc	aaa	gct	gga	ctg	1957
Phe	Glu	Ile	Lys	Lys	Leu	Trp	Glu	Gln	Thr	His	Ser	Lys	Ala	Gly	Leu	
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ctg	gtc	tcc	gac	gga	ggc	cca	aat	tta	tac	aac	att	aga	aat	ctc	cac	2005
Leu	Val	Ser	Asp	Gly	Gly	Pro	Asn	Leu	Tyr	Asn	Ile	Arg	Asn	Leu	His	
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att	cct	gaa	gtc	tgc	ttg	aaa	tgg	gaa	tta	atg	gat	gag	gat	tac	cag	2053
Ile	Pro	Glu	Val	Cys	Leu	Lys	Trp	Glu	Leu	Met	Asp	Glu	Asp	Tyr	Gln	
				610				615						620		
ggg	cgt	tta	tgc	aac	cca	ctg	aac	cca	ttt	gtc	aac	cat	aaa	gac	att	2101
Gly	Arg	Leu	Cys	Asn	Pro	Leu	Asn	Pro	Phe	Val	Asn	His	Lys	Asp	Ile	
			625					630					635			
gaa	tca	gtg	aac	aat	gca	gtg	ata	atg	cca	gca	cat	ggt	cca	gcc	aaa	2149
Glu	Ser	Val	Asn	Asn	Ala	Val	Ile	Met	Pro	Ala	His	Gly	Pro	Ala	Lys	
		640					645					650				
aac	atg	gag	tat	gat	gct	gtt	gca	aca	aca	cac	tcc	tgg	atc	ccc	aaa	2197
Asn	Met	Glu	Tyr	Asp	Ala	Val	Ala	Thr	Thr	His	Ser	Trp	Ile	Pro	Lys	
	655					660					665					

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Arg Asn Arg Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp
670 675 680 685

gaa caa atg tac caa aag tgc tgc aac tta ttt gaa aaa ttc ttc ccc 2293
Glu Gln Met Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro
690 695 700

agc agt tca tac aga aga cca gtc ggg ata tcc agt atg gtg gag gct 2341
Ser Ser Ser Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala
705 710 715

atg gtt tcc aga gcc cga att gat gca cga att gat ttc gaa tct gga 2389
Met Val Ser Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly
720 725 730

agg ata aag aaa gag gag ttc act gag atc atg aag atc tgt tcc acc 2437
Arg Ile Lys Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr
735 740 745

att gaa gag ctc aga cgg caa aaa tagtgaattt agcttgctct tcatgaaaaa 2491
Ile Glu Glu Leu Arg Arg Gln Lys
750 755

atgccttggt tctactaata acccgcggc ccaaaatgcc gactcggagc gaaagatata 2551

cctcccccg ggccgggagg tcgcgtcacc gaccacgcc cgggcccagg cgacgcgcga 2611

cacggacacc tgtcccaaaa aacgccacca tcgcagccac acacggagcg cccggggccc 2671

tctggtcaac cccaggacac acgcgggagc agcgccgggc cggggacgcc ctcccggccg 2731

cccgtgccac acgcaggggg ccggcccgtg tctccagagc gggagccgga agcattttcg 2791

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Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
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Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asn Lys
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Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
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Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Arg
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Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
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Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
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Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
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Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
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Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
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Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
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Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
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Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg Thr Gln Ile
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Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Glu Pro
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Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Ile Ile Asp Gly Thr
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Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
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 Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
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 Arg Phe Tyr Arg Thr Cys Lys Leu Val Gly Ile Asn Met Ser Lys Lys
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	Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro														
	1 5 10														
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Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu															
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121

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<211> 757

<212> PRT

<213> Artificial Sequence

<223> Description of Artificial Sequence: pHL3258

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Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr Gly Ala Pro
 50             55             60

Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn Glu Pro Ser
 65             70             75

Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala Phe Leu Glu
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Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
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Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly Arg Gln Thr
      115          120          125

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Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala Asn Glu Ser
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Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser Met Asn Lys
165 170 175

Glu Glu Met Glu Ile Thr Thr His Phe Gln Arg Lys Arg Arg Val Arg
180 185 190

Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile Gly Lys Arg
195 200 205

Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala Leu Thr Leu
210 215 220

Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
225 230 235 240

Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
245 250 255

Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
260 265 270

Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
275 280 285

Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr Ile Thr Gly
290 295 300

Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
305 310 315 320

Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
325 330 335

Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
340 345 350

Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg Thr Gln Ile
355 360 365

Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Glu Pro
370 375 380

Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile Asp Gly Thr
385 390 395 400

Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
405 410 415

Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg His Thr
420 425 430

Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
435 440 445

Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asn
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Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met Ser Lys Lys
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Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
485 490 495

Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
500 505 510

Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
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Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
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Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
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Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Ile
565 570 575

Lys Lys Leu Trp Glu Gln Thr His Ser Lys Ala Gly Leu Leu Val Ser
580 585 590

Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
595 600 605

Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
610 615 620

Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile Glu Ser Val
625 630 635 640

Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys Asn Met Glu
645 650 655

Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670

Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685

Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700

Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720

Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
725 730 735

Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
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Leu Arg Arg Gln Lys
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<211> 5169

<212> DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence: pHL3259

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<221> CDS

<222> (191)..(2461)

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acaaagtgtc gcccgagta ctggtcgacc tccgaagttg ggggggagcg aaagcaggca 180
aaccatttga atg gat gtc aat ccg act tta ctt ttc tta aaa gtg cca 229
Met Asp Val Asn Pro Thr Leu Leu Phe Leu Lys Val Pro
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Ala Gln Asn Ala Ile Ser Thr Thr Phe Pro Tyr Thr Gly Asp Pro Pro
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tac agc cat ggg aca gga aca gga tac acc atg gat act gtc aac agg 325
Tyr Ser His Gly Thr Gly Thr Gly Tyr Thr Met Asp Thr Val Asn Arg
30 35 40 45
aca cat cag tac tca gaa agg gga aga tgg aca aca aac acc gaa act 373
Thr His Gln Tyr Ser Glu Arg Gly Arg Trp Thr Thr Asn Thr Glu Thr
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Gly Ala Pro Gln Leu Asn Pro Ile Asp Gly Pro Leu Pro Glu Asp Asn
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Glu Pro Ser Gly Tyr Ala Gln Thr Asp Cys Val Leu Glu Ala Met Ala
80 85 90
ttc ctt gag gaa tcc cat cct ggt atc ttt gag acc tcg tgt ctt gaa 517
Phe Leu Glu Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu
95 100 105
acg atg gag gtt gtt cag caa aca cga gtg gac aag ctg aca caa ggc 565
Thr Met Glu Val Val Gln Gln Thr Arg Val Asp Lys Leu Thr Gln Gly
110 115 120 125
cga cag acc tat gac tgg act cta aat agg aac cag cct gct gca aca 613
Arg Gln Thr Tyr Asp Trp Thr Leu Asn Arg Asn Gln Pro Ala Ala Thr
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gca ttg gcc aac aca ata gaa gtg ttc aga tca aat ggc ctc acg gcc 661
Ala Leu Ala Asn Thr Ile Glu Val Phe Arg Ser Asn Gly Leu Thr Ala
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aat gaa tct gga agg ctc ata gac ttc ctt aag gat gta atg gag tca 709
Asn Glu Ser Gly Arg Leu Ile Asp Phe Leu Lys Asp Val Met Glu Ser
160 165 170
atg aac aaa gaa gaa atg gag atc aca act cat ttt cag aga aag aga 757
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175 180 185
cga gtg aga gac aat atg act aag aaa atg gtg aca cag aga aca ata 805
Arg Val Arg Asp Asn Met Thr Lys Lys Met Val Thr Gln Arg Thr Ile
190 195 200 205
ggt aaa agg aag cag aga ttg aac aaa agg agt tat cta att agg gca 853
Gly Lys Arg Lys Gln Arg Leu Asn Lys Arg Ser Tyr Leu Ile Arg Ala
210 215 220
tta acc ctg aac aca atg acc aaa gat gct gag aga ggg aag cta aaa 901
Leu Thr Leu Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys
225 230 235

128

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Phe Val Glu Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser	
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Phe Leu Ala Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe	
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Asn Glu Pro Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile	
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Ser Phe Phe Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu	
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ccc agc ttt gga gta tca gga att aat gaa tcg gct gat atg agc att	1765
Pro Ser Phe Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile	
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131

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<211> 757

<212> PRT

<213> Artificial Sequence

<223> Description of Artificial Sequence: pHL3259

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Gly	Thr	Gly	Thr	Gly	Tyr	Thr	Met	Asp	Thr	Val	Asn	Arg	Thr	His	Gln
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Tyr	Ser	Glu	Arg	Gly	Arg	Trp	Thr	Thr	Asn	Thr	Glu	Thr	Gly	Ala	Pro
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Gln	Leu	Asn	Pro	Ile	Asp	Gly	Pro	Leu	Pro	Glu	Asp	Asn	Glu	Pro	Ser
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Gly	Tyr	Ala	Gln	Thr	Asp	Cys	Val	Leu	Glu	Ala	Met	Ala	Phe	Leu	Glu
				85					90					95	
Glu	Ser	His	Pro	Gly	Ile	Phe	Glu	Thr	Ser	Cys	Leu	Glu	Thr	Met	Glu
			100					105					110		
Val	Val	Gln	Gln	Thr	Arg	Val	Asp	Lys	Leu	Thr	Gln	Gly	Arg	Gln	Thr
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Asn	Thr	Ile	Glu	Val	Phe	Arg	Ser	Asn	Gly	Leu	Thr	Ala	Asn	Glu	Ser
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Glu	Glu	Met	Glu	Ile	Thr	Thr	His	Phe	Gln	Arg	Lys	Arg	Arg	Val	Arg
		180						185					190		
Asp	Asn	Met	Thr	Lys	Lys	Met	Val	Thr	Gln	Arg	Thr	Ile	Gly	Lys	Arg
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 Asn Thr Met Thr Lys Asp Ala Glu Arg Gly Lys Leu Lys Arg Arg Ala
 225 230 235 240
 Ile Ala Thr Pro Gly Met Gln Ile Arg Gly Phe Val Tyr Phe Val Glu
 245 250 255
 Thr Leu Ala Arg Ser Ile Cys Glu Lys Leu Glu Gln Ser Gly Leu Pro
 260 265 270
 Val Gly Gly Asn Glu Lys Lys Ala Lys Leu Ala Asn Val Val Arg Lys
 275 280 285
 Met Met Thr Asn Ser Gln Asp Thr Glu Ile Ser Phe Thr Ile Thr Gly
 290 295 300
 Asp Asn Thr Lys Trp Asn Glu Asn Gln Asn Pro Arg Met Phe Leu Ala
 305 310 315 320
 Met Ile Thr Tyr Ile Thr Arg Asn Gln Pro Glu Trp Phe Arg Asn Val
 325 330 335
 Leu Ser Ile Ala Pro Ile Met Phe Ser Asn Lys Met Ala Arg Leu Gly
 340 345 350
 Lys Gly Tyr Met Phe Glu Ser Lys Ser Met Lys Ile Arg Thr Gln Ile
 355 360 365
 Pro Ala Glu Met Leu Ala Ser Ile Asp Leu Lys Tyr Phe Asn Glu Pro
 370 375 380
 Thr Arg Lys Lys Ile Glu Lys Ile Arg Pro Leu Leu Ile Asp Gly Thr
 385 390 395 400
 Ala Ser Leu Ser Pro Gly Met Met Met Gly Met Phe Asn Met Leu Ser
 405 410 415
 Thr Val Leu Gly Val Ser Ile Leu Asn Leu Gly Gln Lys Arg His Thr
 420 425 430
 Lys Thr Thr Tyr Trp Trp Asp Gly Leu Gln Ser Ser Asp Asp Phe Ala
 435 440 445
 Leu Ile Val Asn Ala Pro Asn His Glu Gly Ile Gln Ala Gly Val Asn
 450 455 460
 Arg Phe Tyr Arg Thr Cys Lys Leu Leu Gly Ile Asn Met Ser Lys Lys
 465 470 475 480
 Lys Ser Tyr Ile Asn Arg Thr Gly Thr Phe Glu Phe Thr Ser Phe Phe
 485 490 495
 Tyr Arg Tyr Gly Phe Val Ala Asn Phe Ser Met Glu Leu Pro Ser Phe
 500 505 510
 Gly Val Ser Gly Ile Asn Glu Ser Ala Asp Met Ser Ile Gly Val Thr
 515 520 525
 Val Ile Lys Asn Asn Met Ile Asn Asn Asp Leu Gly Pro Ala Thr Ala
 530 535 540
 Gln Met Ala Leu Gln Leu Phe Ile Lys Asp Tyr Arg Tyr Thr Tyr Arg
 545 550 555 560

Cys His Arg Gly Asp Thr Gln Ile Gln Thr Arg Arg Ser Phe Glu Leu
565 570 575

Lys Lys Leu Trp Glu Gln Thr Arg Ser Lys Ala Gly Leu Leu Val Ser
580 585 590

Asp Gly Gly Pro Asn Leu Tyr Asn Ile Arg Asn Leu His Ile Pro Glu
595 600 605

Val Cys Leu Lys Trp Glu Leu Met Asp Glu Asp Tyr Gln Gly Arg Leu
610 615 620

Cys Asn Pro Leu Asn Pro Phe Val Asn His Lys Asp Ile Glu Ser Val
625 630 635 640

Asn Asn Ala Val Ile Met Pro Ala His Gly Pro Ala Lys Asn Met Glu
645 650 655

Tyr Asp Ala Val Ala Thr Thr His Ser Trp Ile Pro Lys Arg Asn Arg
660 665 670

Ser Ile Leu Asn Thr Ser Gln Arg Gly Ile Leu Glu Asp Glu Gln Met
675 680 685

Tyr Gln Lys Cys Cys Asn Leu Phe Glu Lys Phe Phe Pro Ser Ser Ser
690 695 700

Tyr Arg Arg Pro Val Gly Ile Ser Ser Met Val Glu Ala Met Val Ser
705 710 715 720

Arg Ala Arg Ile Asp Ala Arg Ile Asp Phe Glu Ser Gly Arg Ile Lys
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Lys Glu Glu Phe Thr Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
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Leu Arg Arg Gln Lys
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<210> 46
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135

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Glu Ser His Pro Gly Ile Phe Glu Thr Ser Cys Leu Glu Thr Met Glu
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140

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725 730 735

Lys Glu Glu Phe Ala Glu Ile Met Lys Ile Cys Ser Thr Ile Glu Glu
740 745 750

Leu Arg Arg Gln Lys
755

EPO - Munich
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09. Feb. 2001

Claims:

1. A human influenza virus comprising an RNA-sequence encoding a modified RNA-polymerase which differs from the wild-type RNA-polymerase of said human influenza virus in that at least one of the amino acid residue(s) distinguishing the wild-type RNA-polymerase of said human influenza virus from FPV Bratislava RNA-polymerase has been replaced with the corresponding amino acid residue(s) as present in FPV Bratislava RNA-polymerase.
2. The influenza virus of claim 1, which is selected from influenza A including strains of type H1N1, H2N2 and H3N2, influenza B and influenza C, and preferably is an influenza A type H1N1, including WSN/33, PR8/34 or the like, an influenza A type H2N2, including Asia/57 or the like, or an influenza A type H3N2, including Victoria/68 or the like.
3. The influenza virus of claim 1 or 2, wherein the at least one distinguishing amino acid residue to be replaced is located within the PB1 segment of the virus.
4. The influenza virus of claim 3, wherein at least one or all of the following PB1 amino acid substitutions S384P, L396I, L628M, V644A, T741A, relative to the wild-type WSN-PB1 polypeptide shown in SEQ ID NO:25 have been effected, preferably the influenza virus strain used is WSN-K68 carrying five distinguishing amino acids.
5. The influenza virus of claim 3, which encodes the PB1 segment shown in SEQ ID NO:27, 29, 31, 33, 35, 37, 39, 41, 43, 45 or 47, preferably said influenza virus comprises a PB1 (segment2) RNA sequence corresponding to the nucleotide sequence shown in SEQ ID NO:26, 28, 30, 32, 34, 36, 38, 40, 42, 44 or 46.

6. The influenza virus according to any one of claims 1 to 5, wherein the modified RNA-polymerase is capable of recognition of segments with modified vRNA promoter sequences resulting in an enhanced rate of transcription and/or replication relative to said wild-type human influenza virus RNA-polymerase.

7. The influenza virus of claim 6, wherein the segments with modified vRNA promoter sequences contain terminal viral RNA sequences which have been modified by nucleotide substitutions in up to five positions, resulting in improved transcription rates of both the vRNA promoter as well as the cRNA promoter as present in the complementary sequences.

8. The influenza virus of claim 7, wherein the 12 nucleotide conserved influenza 3' terminal sequence has been modified by replacement of one to three nucleotides occurring in said sequence at positions 3, 5 and 8 relative to the 3' end by other nucleotides, and/or wherein the 13 nucleotide conserved influenza 5' terminal sequence has been modified by replacement of one or two nucleotides occurring in said sequence at positions 3 and 8 by other nucleotides.

9. The influenza virus of claim 8, wherein the replacements in the 3' terminal nucleotide sequence comprises the modifications G3A and C8U, or G3C and C8G, preferably the replacements in the 3' terminal nucleotide sequence comprises the modifications G3A, U5C and C8U, or G3C, U5C and C8G.

10. The influenza virus of claim 9, which comprises a 3' terminal nucleotide sequence of (5')-CCUGUUUCUACU-3' or (5')-CCUGUUUUUACU-3'.

11. The influenza virus according to any one of claims 7 to 10, wherein the 5' terminal nucleotide sequence comprises the modifications U3A and A8U resulting in a 5'-terminal sequence of 5'-AGAAGAAUCAAGG.

12. The influenza virus according to any one of claims 1 to 11 which is suitable for high yielding expression of one or more foreign recombinant or altered viral proteins, preferably said influenza virus contains

(i) one or more segment(s) with a foreign recombinant or altered viral gene sequence in addition to the RNA segments of the normal viral genome (additional segment) or partially replacing them (replacing segment), whereby the additional segment(s) and replacing segment(s) comprise the foreign or altered gene encoding the protein to be expressed in monocistronic arrangement and have modified vRNA promoter sequences as defined in claims 7 to 11; and/or

(ii) one or more bicistronic vRNA segment(s), preferably in ambisense or in tandem arrangement, whereby the bicistronic vRNA segment(s) has/have foreign gene(s) encoding the protein(s) to be expressed and being in covalent linkage with one of the authentic viral genes, preferably the neuraminidase gene, and has/have modified vRNA promoter sequences as defined in claims 7 to 11.

13. The influenza viruses according to claim 12 having at least one additional segment coding for one or more foreign genes or one or more altered viral genes in monocistronic arrangement.

14. The influenza virus according to claim 13 in which the at least one additional segment codes for a glycoprotein of foreign-viral, animal, human or other origin, with or without in-frame fusion linkage to influenza coding sequences, in which the glycoprotein is at the same time incorporated itself in the virion envelopes, preferably the foreign glycoprotein sequence incorporated as vRNA and as a protein is derived from the genome of the contagious swine fever virus (CSFV), the bovine viral diarrhea virus (BVDV), the vesicular stomatitis virus (VSV), the Bornavirus (BDV), the Marburg virus, the Ebola virus, the hepatitis C virus, the tick-borne meningoencephalitis virus (TBE), the Western Nile virus or the human immunodeficiency virus (HIV).

15. The influenza virus according to claim 13 in which one or more of the incorporated foreign genes code

(a) for a lymphokine of human or animal origin which is secreted by the influenza vector infected cell, or

(b) for the expression of an apoptosis-inducing gene or a toxin gene, effective in the primarily infected cell or, after secretion, in neighboring cells.

16. The influenza virus of claim 12, which is genetically stable in the absence of any helper virus and which comprises at least one viral RNA segment being an ambisense RNA molecule (ambisense RNA segment) and containing one of the standard viral genes in sense orientation and a foreign, recombinant gene in anti-sense orientation, or *vice versa*, in overall convergent arrangement.

17. The influenza virus of claim 16, wherein at least one of the regular viral RNA segments is replaced by an ambisense RNA segment which contains one of the standard viral genes in sense orientation and a foreign, recombinant gene in anti-sense orientation, or *vice versa*, in overall convergent arrangement.

18. The influenza virus of claim 16 or 17, wherein in the ambisense RNA molecule said foreign recombinant gene is covalently bound to one of the viral genes, while the original vRNA segment coding for the same gene is deleted from the recombinant virus by way of specific ribozyme cleavage or is left out from the set of RNA-polymerase I promoted vRNA synthesizing plasmids, able to result in infectious viruses.

19. The influenza virus according to any one of claims 16 to 18, wherein one or more of the standard viral RNA segments, differing from said at least one ambisense RNA segment, comprises a vRNA encoding a foreign gene, preferably one or more of the regular viral RNA segments has

(have) been exchanged for a vRNA encoding a foreign gene, preferably one or both of the standard glycoproteins hemagglutinin and neuraminidase have been exchanged into foreign glycoprotein(s) or into fusion glycoproteins consisting of an anchor segment derived from hemagglutinin and an ectodomain obtained from the foreign source, viral or cellular, or in which such recombinant glycoprotein has been inserted as a third molecular species in addition to the remaining standard components.

20. The influenza virus of claim 12, which is genetically stable in the absence of any helper virus and which comprises at least one viral RNA segment being a bicistronic RNA molecule coding for two genes in tandem arrangement (tandem RNA segment), in said tandem RNA segment one of the standard viral genes being in covalent junction with a foreign, recombinant gene and said tandem RNA segment having an upstream splice donor and a downstream splice acceptor signal surrounding the proximal coding region.

21. The influenza virus of claim 20, wherein the tandem RNA segment contains one of the standard viral genes in distal mRNA position behind a foreign, recombinant gene in proximal position, or vice versa, both in antisense orientation with regard to the viral RNA as present within the virus.

22. The influenza virus of claim 20 or 21, wherein at least one of the regular viral RNA segments is replaced by a tandem RNA segment, preferably the replaced regular viral RNA segment is selected from the neuraminidase segment, hemagglutinin segment and NS segment.

23. The influenza virus according to any one of claims 20 to 22, wherein the splice donor and splice acceptor signals are selected from sequences as present in influenza WSN segment 7 and 8 or other partially effective splice reacting substrates, preferably the splice donor and splice acceptor

signals are selected from sequences as present in influenza WSN segment 7.

24. The influenza virus according to any one of claims 20 to 23, wherein one or more of the regular viral RNA segments, differing from said at least one tandem RNA segment, comprises a vRNA encoding a foreign gene which may or may not be in covalent connection to one of the viral genes, and preferably one or more of the regular viral RNA segments has (have) been deleted and replaced by a tandem vRNA encoding in addition a foreign gene.

25. The influenza virus according to any one of claims 20 to 24, in which the foreign gene(s) in the tandem RNA segment

- (i) code for proteins and/or glycoproteins which are secreted from cells infected with the recombinant virus;
- (ii) code for proteins or artificial polypeptides designed to support an efficient HLA-restricted presentation of inherent epitopes at the surface of infected cells, for stimulation of a B cell and/or T cell response;
- (iii) is a nucleotide sequence causing viral attenuation, preferably the foreign gene is coding for part of the viral neuraminidase gene in inverted, i.e. sense orientation, with or without an inserted ribozyme sequence,

preferably the tandem segment part of the neuraminidase gene in sense orientation is attached to the hemagglutinin vRNA segment, and optionally another gene or reporter gene is encoded in a second tandem vRNA, preferably in conjunction with NS2.

26. The influenza virus according to any one of claims 16 to 25 which is suitable for the expression of non-influenza genes or synthetic genes, or gene-inhibitory sequences such as, but not limited to, antisense genes or ribozymes, whereby

- (i) the non-influenza genes are covalently linked to one of the viral genes,
- (ii) the non-influenza gene constitutes a membrane glycoprotein consisting of a fusion of the viral HA transmembrane and cytoplasmic regions with the foreign ectodomain sequence.

27. A non-avian, non-human influenza virus, preferably an equine or a porcine influenza virus comprising an RNA-sequence encoding a modified RNA-polymerase which differs from the wild-type RNA-polymerase of said non-avian, non-human influenza virus in that at least one of the amino acid residue(s) distinguishing the wild-type RNA-polymerase of said non-avian, non-human influenza virus from FPV Bratislava RNA-polymerase has been replaced with the corresponding amino acid residue(s) as present in FPV Bratislava RNA-polymerase, preferably said influenza virus is as defined in any one of claims 2 to 26.

28. A process for preparing the influenza virus of claims 1 to 27 which comprises replacing the RNA-sequence encoding the wild-type RNA-polymerase of said influenza virus with an RNA-sequence encoding the modified RNA-polymerase.

29. The process of claim 28, which is suitable for preparing PB1-chimeric viruses as defined in claims 1 to 11 and 27 as well as recombinant viruses as defined in claims 12 to 27, said viruses being generated via cotransfection of up to eight cDNA plasmids containing the viral cDNAs, or chimeric (segment 2: PB1) and bicistronic recombinant (segment 6: NA/foreign gene) cDNA sequences instead, in such a way that they are transcribed *in vivo* by both RNA-polymerase I and RNA-polymerase II and jointly give rise to progeny viruses according to the plasmid insert design.

30. A pharmaceutical composition comprising the influenza virus according to any one of claims 1 to 27.

31. The pharmaceutical composition of claim 30 which is suitable

- (i) for gene transfer into cells, preferably into mammalian cells, more preferably into human cells, by recombinant viral infection;
- (ii) for gene transfer into antigen-presenting cells, preferably into dendritic cells, and the use of the obtained product for *ex vivo* immunotherapy;
- (iii) for *in vivo* somatic gene therapy;
- (iv) for *in vivo* vaccination, including therapeutic and prophylactic vaccination;
- (v) for eliciting an immune response, including the induction of a T-cell response;
- (vi) for treating a growing tumor or a chronic infectious disease.

32. Use of the influenza virus according to any one of claims 1 to 27 for preparing an agent

- (i) for gene transfer into cells, preferably into mammalian cells, more preferably into human cells, by viral infection;
- (ii) for gene transfer into antigen-presenting cells and the use of the obtained product for *ex vivo* immunotherapy;
- (iii) for *in vivo* somatic gene therapy;
- (iv) for *in vivo* vaccination, including therapeutic and prophylactic vaccination;
- (v) for eliciting an immune response, including the induction of a T-cell response;
- (vi) for treating a growing tumor or a chronic infectious disease.

33. A method for

- (i) gene transfer into cells, preferably into mammalian cells, more preferably into human cells, by viral infection;
- (ii) gene transfer into antigen-presenting cells, and the use of the obtained product for *ex vivo* immunotherapy;
- (iii) *in vivo* somatic gene therapy;
- (iv) *in vivo* vaccination, including therapeutic and prophylactic vaccination;

(v) eliciting an immune response, including the induction of a T-cell response, preferably a CD4+ T-cell response, a CD8 T-cell response or both, or the induction of an antibody response;

(vi) treating a growing tumor or a chronic infectious disease;

(vii) preparing a vaccine;

(viii) preventing and/or treating influenza;

which comprises contacting the cells, the antigen-presenting cells, the person or the patient in need for vaccination, for influenza treatment or for somatic gene therapy, or cell cultures with the influenza virus according to any one of claims 1 to 27.

34. A method for the production of proteins or glycoproteins which comprises utilizing the influenza virus according to claims 1 to 27 as expression vector, preferably the production method is performed in cell culture cells or in fertilized chicken eggs.

35. Use of the influenza virus according to claims 1 to 27 for preparing agents

(i) for transfer and expression of foreign genes into cells infected by such viruses, or

(ii) for transfer and expression of RNA molecules into cells infected by such viruses, preferably the RNA molecules to be expressed are antisense sequences or double-strand sequences relative to the target cell cellular mRNA molecules, and/or the agent is suitable for sequence-specific gene silencing, preferably by antisense RNA or RNA interference mechanisms such as ribozyme cleavages of target RNAs.

36. A method for transfer and expression of foreign genes into cells, and for transfer and expression of RNA molecules into cells, which method comprises infecting the cells with the influenza virus according to claims 1 to 27.

37. Use of the influenza virus according to claims 1 to 27 for preparing agents for immunotherapy, preferably for autologous immunotherapy.

38. A method for an immunotherapy which comprises *ex vivo* infection of immune cells, preferably dendritic cells, with the influenza virus according to claims 1 to 27, and introduction of the transduced cells into the patient.

39. A method to elicit an immune response directed against an antigen, comprising the steps of introducing the influenza virus as defined in claims 1 to 27, preferably the human influenza virus as defined in claims 1 to 26, into a cell or administering it to a mammal, wherein said influenza virus contains at least one foreign gene encoding the antigen.

40. The method of claim 39, wherein said foreign gene encoding the antigen is a polynucleotide sequence associated with a disease, preferably an infectious diseases, or a tumor disease, preferably the antigen is exemplified by, but not limited to,

- (i) virus-associated antigens such as the HIV antigens gp160, gp 120, rev, tat, NC, the HBV e-antigen or core antigen, the HPV E6 or E7 antigen, the herpes simplex virus glycoproteins or core proteins, other herpesvirus antigens and further viral and microbial antigens known to those skilled in the art, or
- (ii) tumor associated antigens, especially the so-called cancer testis-antigens exemplified by the MAGE, BAGE and GAGE family of antigens, the NY-ESO-1 antigen, the SSX antigens, exemplified by the HOM-MEL-40.

41. The method of claim 39 or 40, wherein the polynucleotide sequence

- (i) is derivable from a cDNA library isolated from tumor cells, or testis cells, or virus-infected cells, or microbially infected cells, or cell-lines,

- (ii) is a fusion protein consisting of epitopes derived from one or more T-cell specific epitope sequences as present in viral or other pathogens, or in tumor associated antigens.

42. A vaccine for therapeutic or prophylactic purposes which is

- (a) a human influenza virus vaccine comprising a human influenza virus as defined in claims 1 to 26 or in claims 39 to 41, preferably said human influenza virus encodes the antigen for a membrane protein and in addition contains the membrane protein in the viral envelope; or
- (b) a non-human influenza virus vaccine, preferably an equine or porcine influenza virus vaccine, comprising a virus as defined in claim 27.

43. The vaccine according to claim 42, wherein the virus

- (i) is capable of being attenuated according to the tandem attenuation mechanism;
- (ii) is only capable of limited replication; or
- (iii) is an inactivated virus.

44. Transduced cells, preferably antigen-presenting cells, obtainable by the method of claim 33, option (i) or (ii).

45. A vaccine comprising transduced cells as defined in claim 44, preferably comprising transduced antigen-presenting cells, more preferably transduced dendritic cells, and most preferably mature dendritic cells, wherein said antigen-presenting cells are transduced *in vitro*.

46. A method to identify a polynucleotide sequence encoding at least one HLA-restricted epitope comprising the steps of

- (a) preparing a gene bank or a cDNA bank from the cell or the microorganism to be tested;
- (b) incorporating the cDNA or the DNA of the gene bank into the genome of the influenza virus as defined in claims 1 to 27 to yield recombinant virus particles,

- (c) infecting immortalized autologous cells, which are capable of expression of HLA-class I molecules and/or HLA-class II molecules on their surface, with the recombinant virus particles obtained in step (b),
- (d) expressing the proteins encoded by said cDNA or said DNA of the gene bank in the autologous cells and presenting the fragments of the proteins produced by the autologous cells or the cell surface in connection with HLA molecules;
- (e) co-cultivating T-cells with the autologous cells; and
- (f) stimulating the T-cells by such autologous cells which present antigens on their surface, whereby said antigens are recognized by the T-cells.

47. A method to study gene function in antigen presenting cells comprising steps (a) to (f) of claim 46.

Abstract

The present invention provides human influenza viruses comprising an RNA-sequence encoding a modified RNA-polymerase, a process for the preparation thereof, pharmaceutical compositions comprising said human influenza viruses and their use for gene transfer into mammalian cells, for *ex vivo* gene transfer into antigen-presenting cells, such as dendritic cells, for *in vivo* somatic gene therapy, or *in vivo* vaccination purposes. The invention also relates to other non-avian influenza viruses, including equine, porcine (swine) influenza viruses.

FIG. 1

		PB1: Positions											
Type	Origin	52	54	105	175	208	298	364	383	384	396	431	464
H7N7	Bratislava 82 chicken	K	K	N	D	K	L	L	E	P	I	Y	D
H7N7	Rostock34 chicken	K	K	N	D	K	L	L	E	S	L	Y	D
H1N1	WSN33 human	R	R	T	N	R	I	I	D	S	L	H	N
H1N1	Wisconsin88 human	R	K	N	E	K	L	L	D	S	L	Y	D
H2N2	Singapore57 human	K	K	N	D	K	L	L	E	S	L	Y	D
H2N2	Ann Arbor60 human	K	K	N	D	K	L	L	E	S	L	Y	D
H3N2	Honkong68 human	K	K	N	D	K	L	L	E	S	L	Y	D
H3N2	Shiga97 human	K	K	N	D	K	L	L	E	S	L	Y	D
H3N2	Hongkong82 swine	K	K	N	D	K	L	L	E	S	L	Y	D
H3N2	Katakyushu93 human	R	K	N	D	K	L	L	E	S	L	Y	D
H3N8	Tennessee86 equine	K	K	N	N	K	L	L	E	S	L	Y	D
H4N2	Minnesota80 turkey	K	K	N	D	K	L	L	E	S	L	Y	D
H4N6	Ontario99 swine	K	K	N	D	K	L	L	E	S	L	Y	D
H5N1	Hongkong97 human	K	R	N	D	K	L	L	E	S	L	Y	D
H6N1	Taiwan99 chicken	K	K	N	D	K	L	L	E	S	L	Y	D
H7N7	London73 equine	K	K	N	D	K	L	L	D	S	L	Y	D
H9N2	Pakistan99 chicken	K	K	N	D	K	L	L	E	S	L	Y	D

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FIG 1 (continued)

PB1: Positions												
Type	Origin	473	576	584	628	633	636	644	645	654	741	
H7N7	Bratislava 82 chicken	V	L	R	M	S	E	A	V	S	A	
H7N7	Rostock34 chicken	V	L	R	L	S	E	V	V	S	A	
H1N1	WSN33 human	L	I	H	L	N	D	V	I	N	I	
H1N1	Wisconsin88 human	L	I	R	L	S	E	V	V	T	A	
H2N2	Singapore57 human	V	L	R	L	S	E	V	V	S	A	
H2N2	Ann Arbor60 human	V	L	R	L	S	E	V	V	S	A	
H3N2	Honkong68 human	V	L	Q	L	S	E	V	V	S	S	
H3N2	Shiga97 human	V	L	Q	L	S	E	V	V	S	S	
H3N2	Hongkong82 swine	V	L	R	L	S	E	V	V	S	A	
H3N2	Katakushu93 human	V	L	Q	L	S	E	V	V	S	S	
H3N8	Tennessee86 equine	V	L	R	L	S	E	V	V	S	A	
H4N2	Minnesota80 turkey	V	L	R	L	S	E	V	V	N	A	
H4N6	Ontario99 swine	V	L	R	L	S	E	V	V	S	A	
H5N1	Hongkong97 human	V	L	R	L	S	E	V	V	S	A	
H6N1	Taiwan99 chicken	V	L	R	L	S	E	V	V	S	A	
H7N7	London73 equine	V	L	R	L	S	E	V	V	S	A	
H9N2	Pakistan99 chicken	V	L	R	L	S	E	V	V	S	A	

Fig.2

plasmid	constitution						other segments	orig.titer	CAT assay	
	v1 / c1	x3'	c2	S L P I	x5'	H R	L V MA	v2	T	A
map PB1										
WSN-PB1	WSN						WSN	7x10 ⁸ /ml	11	2
pHL3102		WSN				FPV				
pHL3103		FPV				WSN				
pHL3130		WSN			FPV					
pHL3131		WSN		FPV		WSN				
pHL3115				FPV						
pHL1844				FPV			FPV			

Fig.3

plasmid	constitution										other segments	orig.titer	CAT assay	
map PB1	v1 / c1	x3'	c2	S L P	x5'	H R	L V MA	v2	T A				293T	MDCK
WSN-PB1			WSN								WSN	7x10 ⁸ /ml	11	2
pHL3204					FPV						WSN	2x10 ⁸ /ml	12	3
pHL3203							FPV				WSN	1x10 ⁸ /ml	24	42
pHL3246			FPV								WSN	3x10 ⁸ /ml	10	3
pHL3247				FPV							WSN	4x10 ⁶ /ml	20	29
pHL3258											WSN	1x10 ⁷ /ml	28	50
pHL3259					FPV						WSN	3x10 ⁷ /ml	32	61
pHL3268							FPV				WSN	3x10 ⁷ /ml	39	71
pHL1844			FPV								FPV	3x10 ⁹ /ml	48	100

Fig. 4

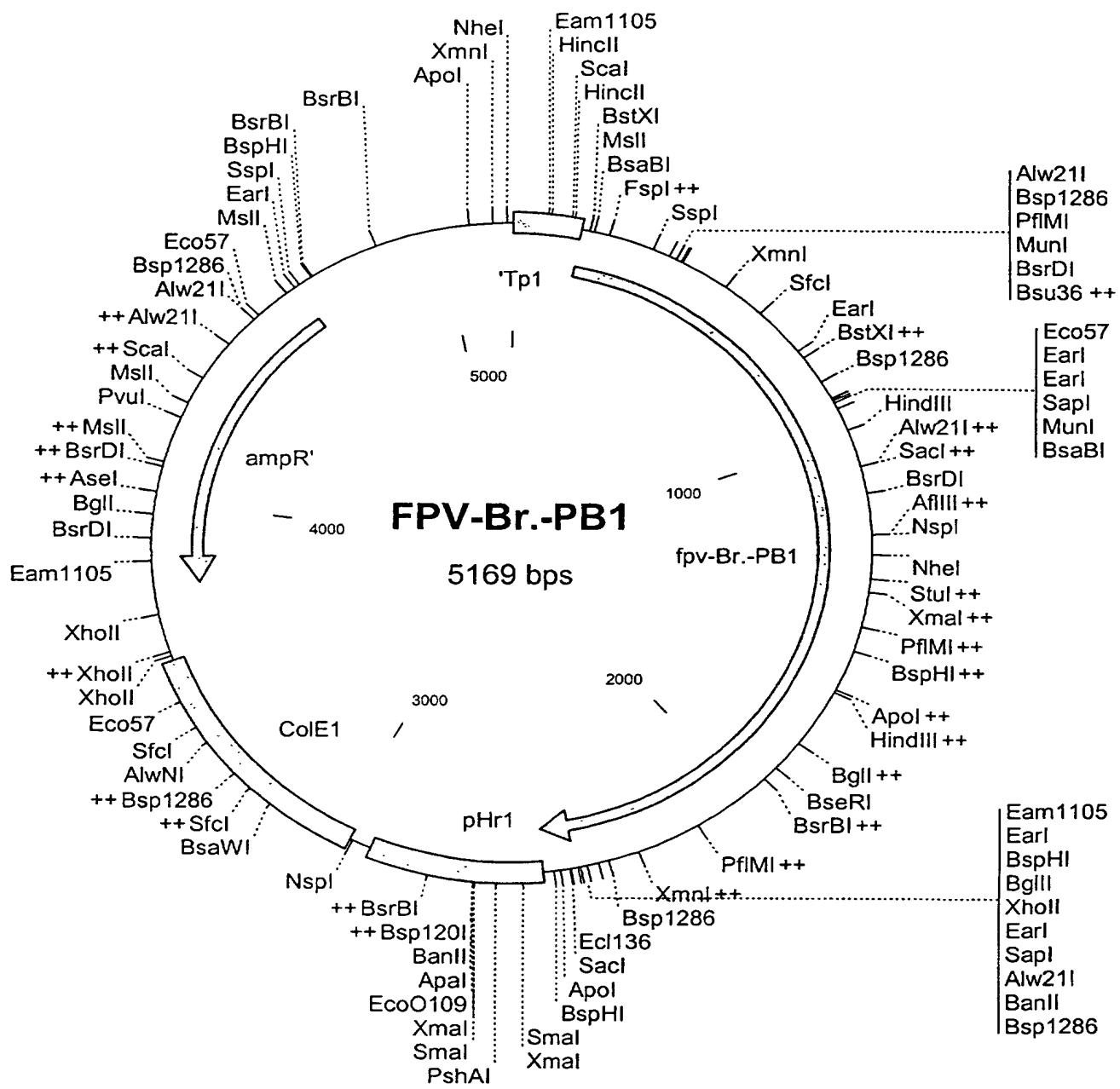


Fig. 5

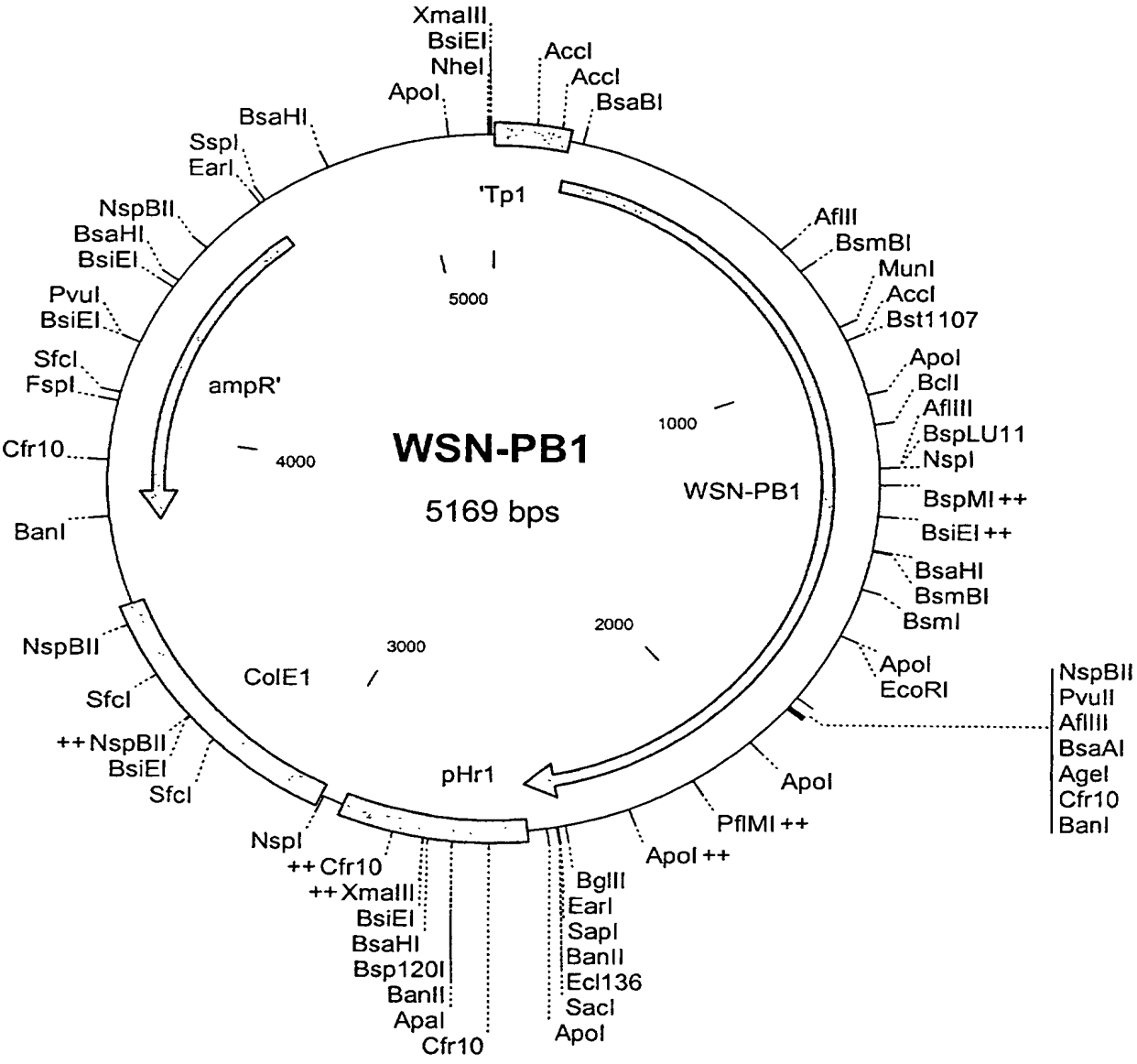


Fig. 6

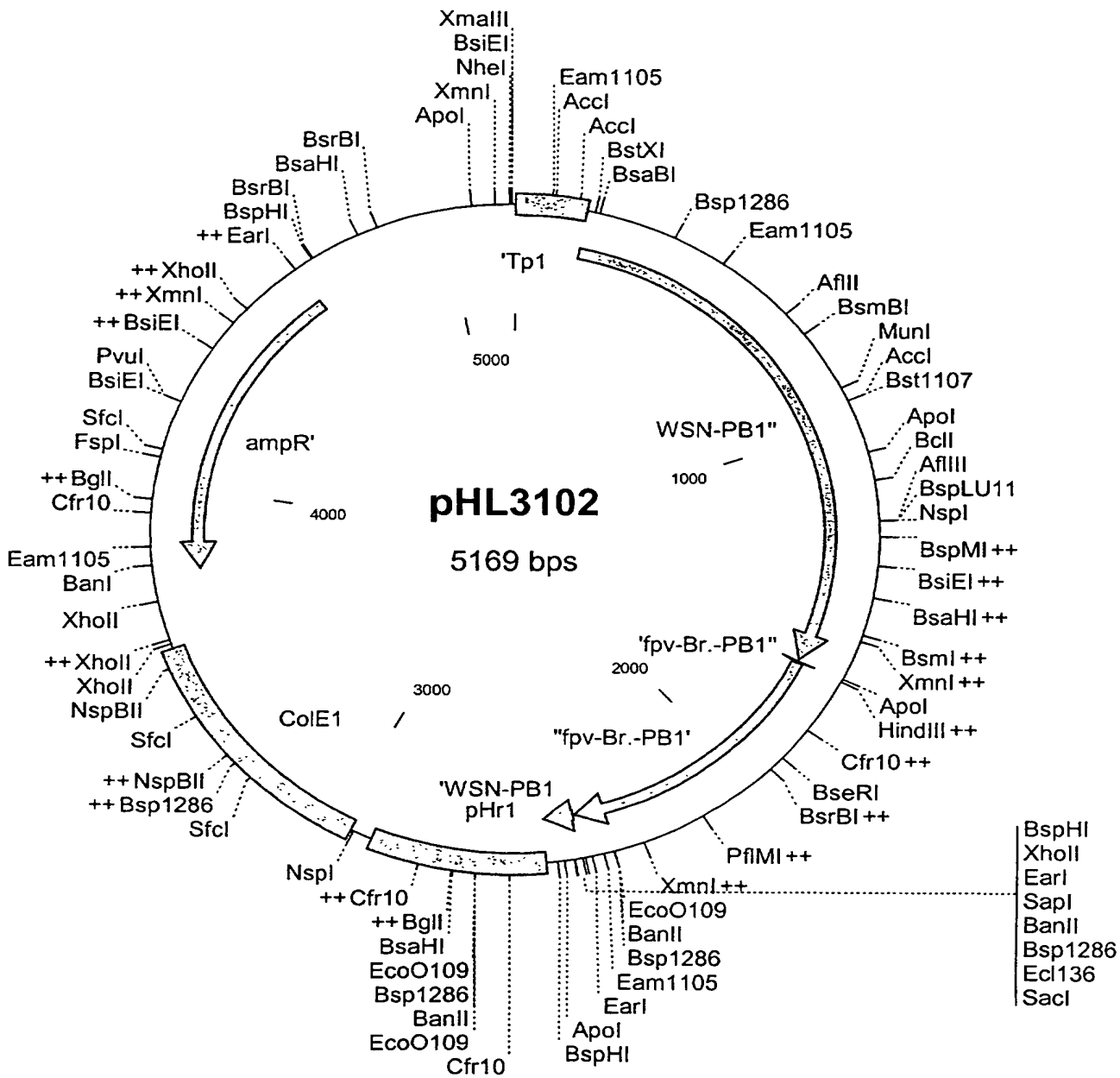


Fig. 7

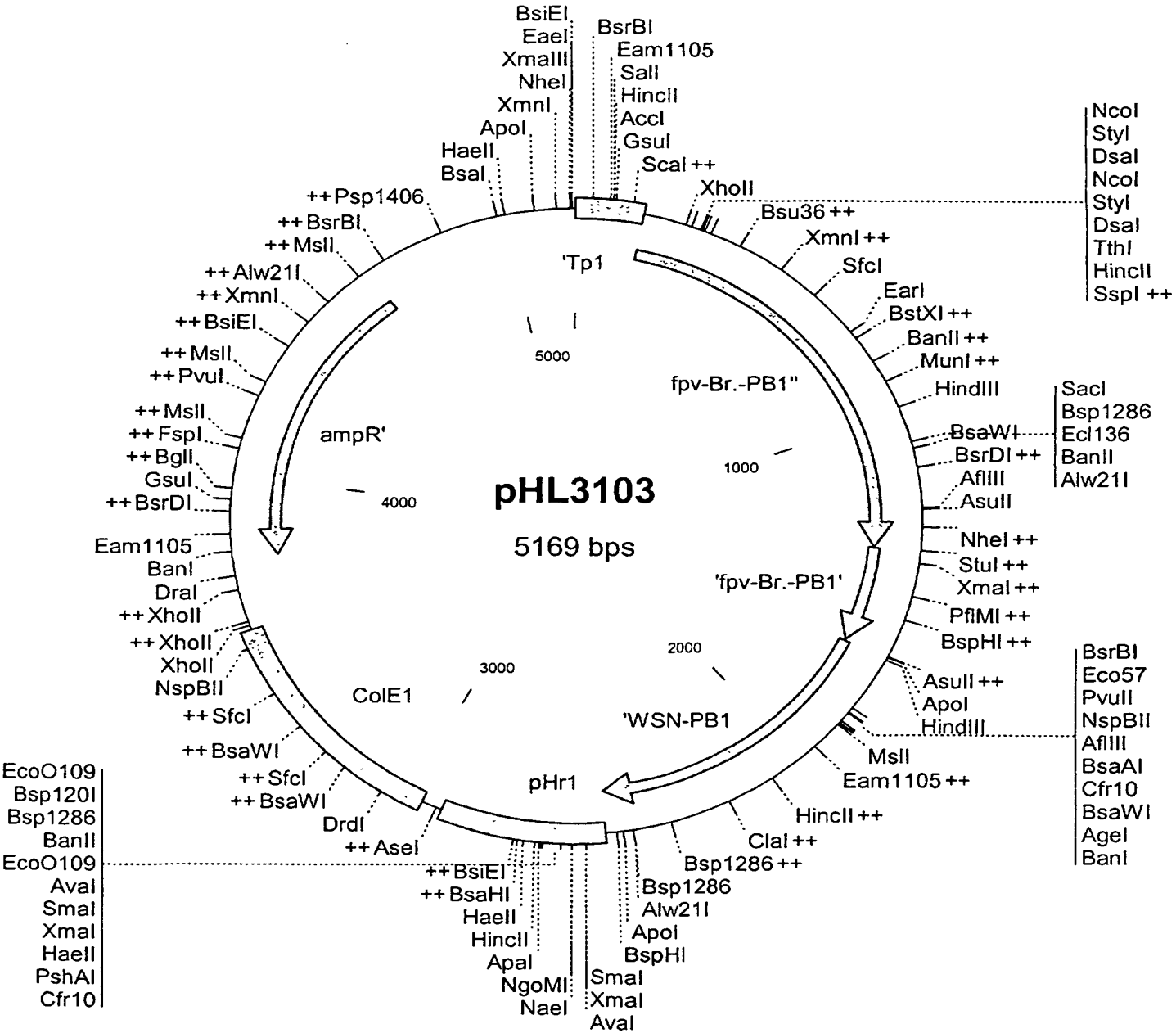


Fig. 9

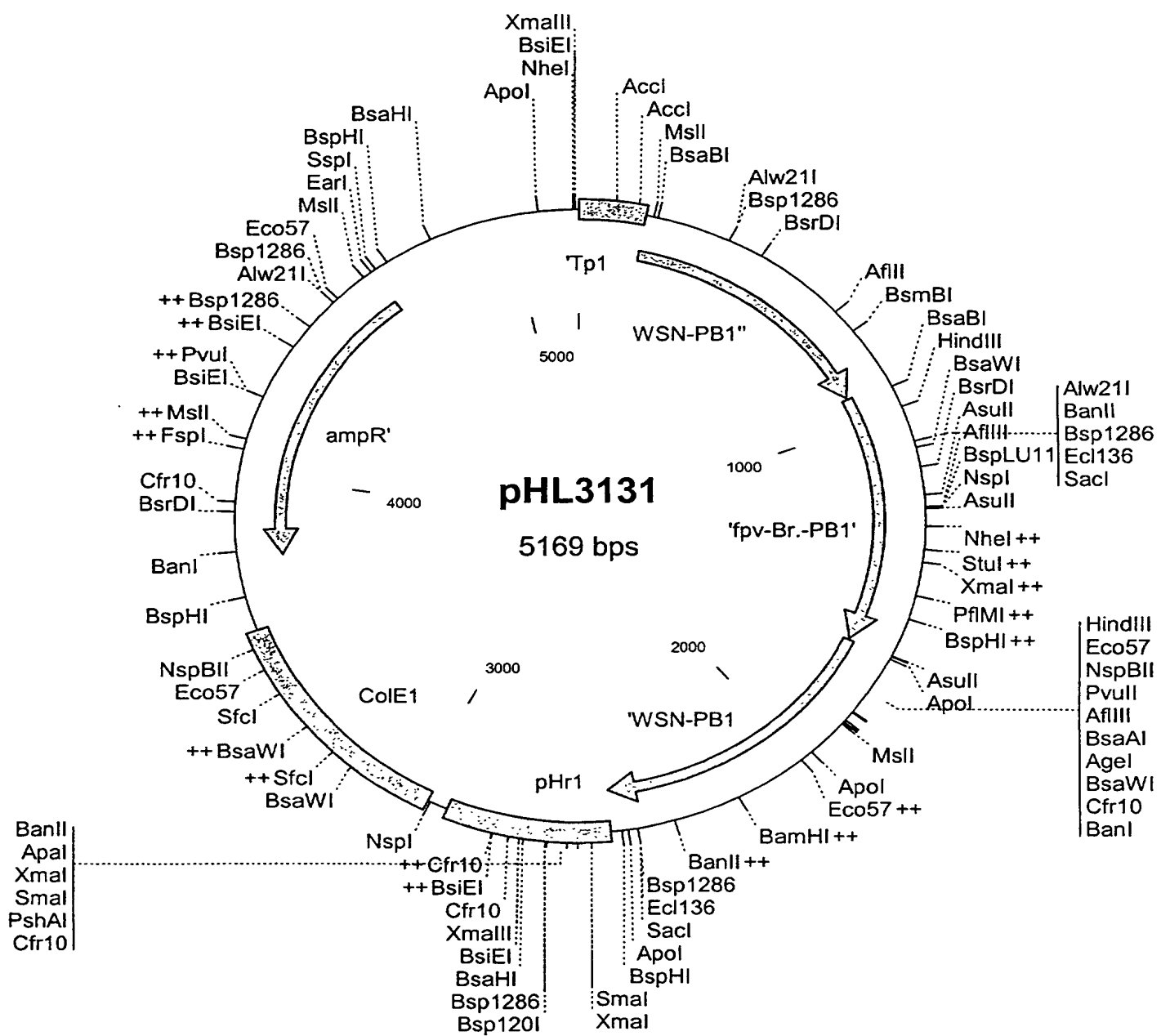


Fig. 10

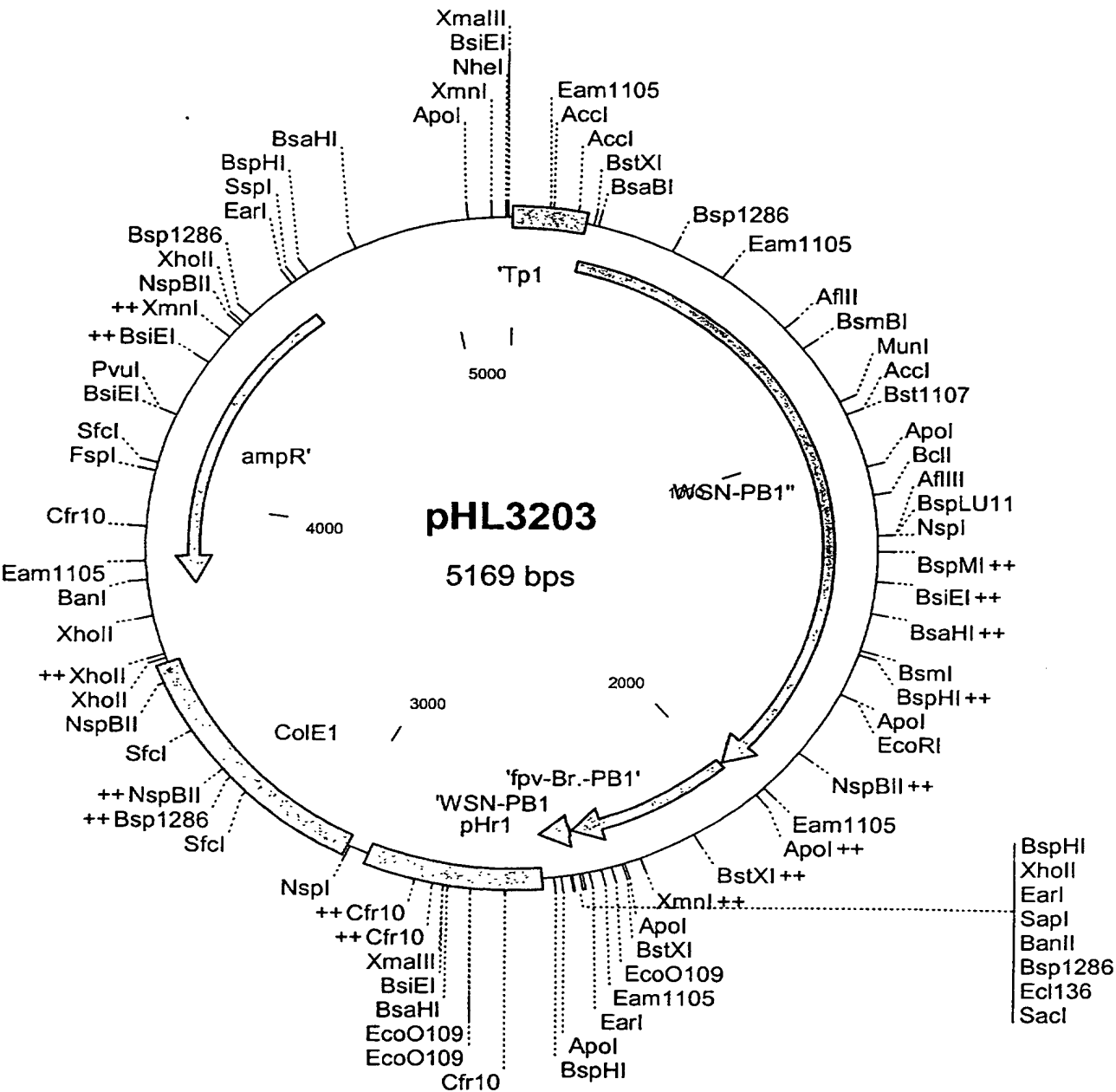


Fig. 11

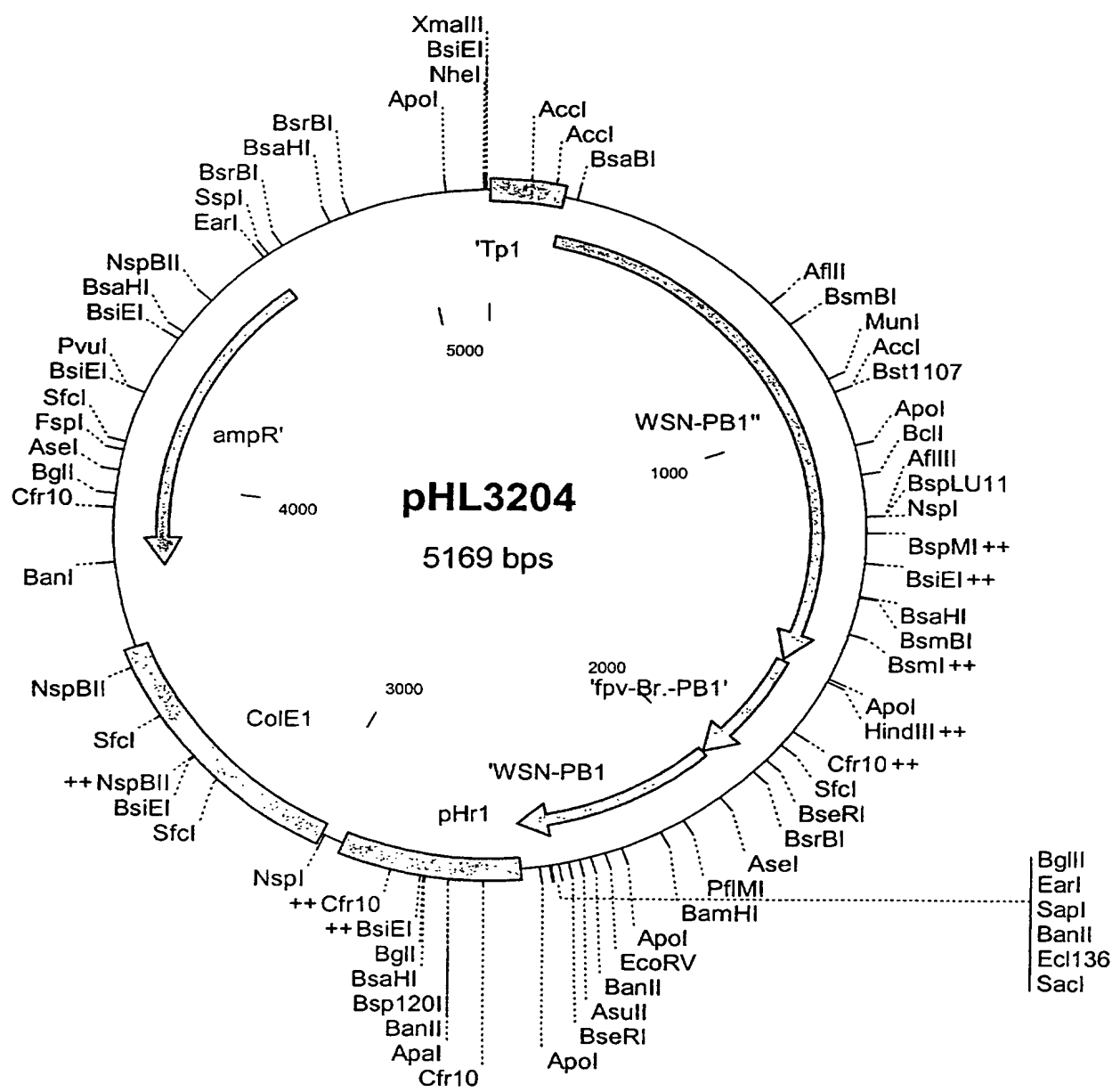


Fig. 12

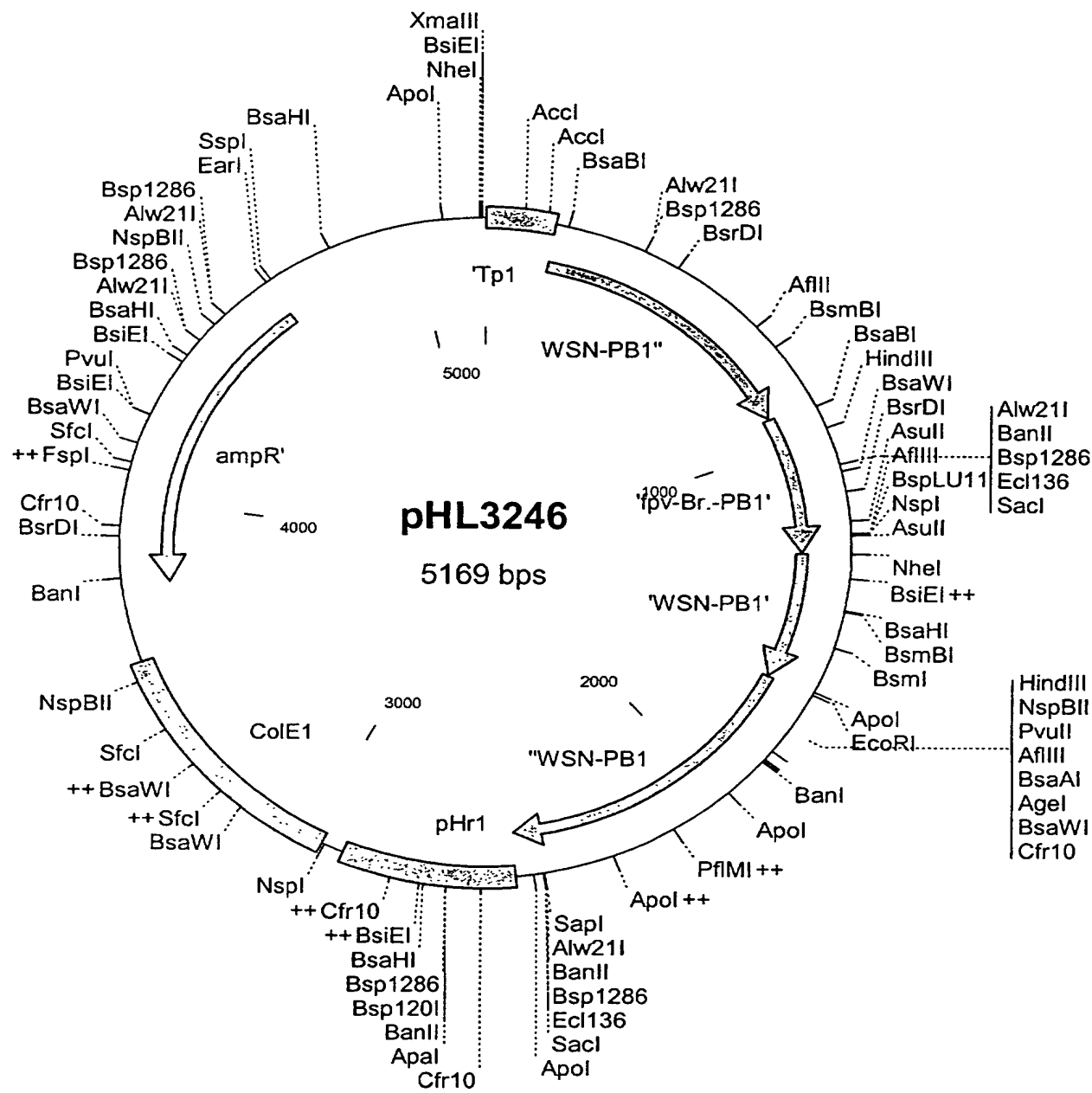


Fig. 13

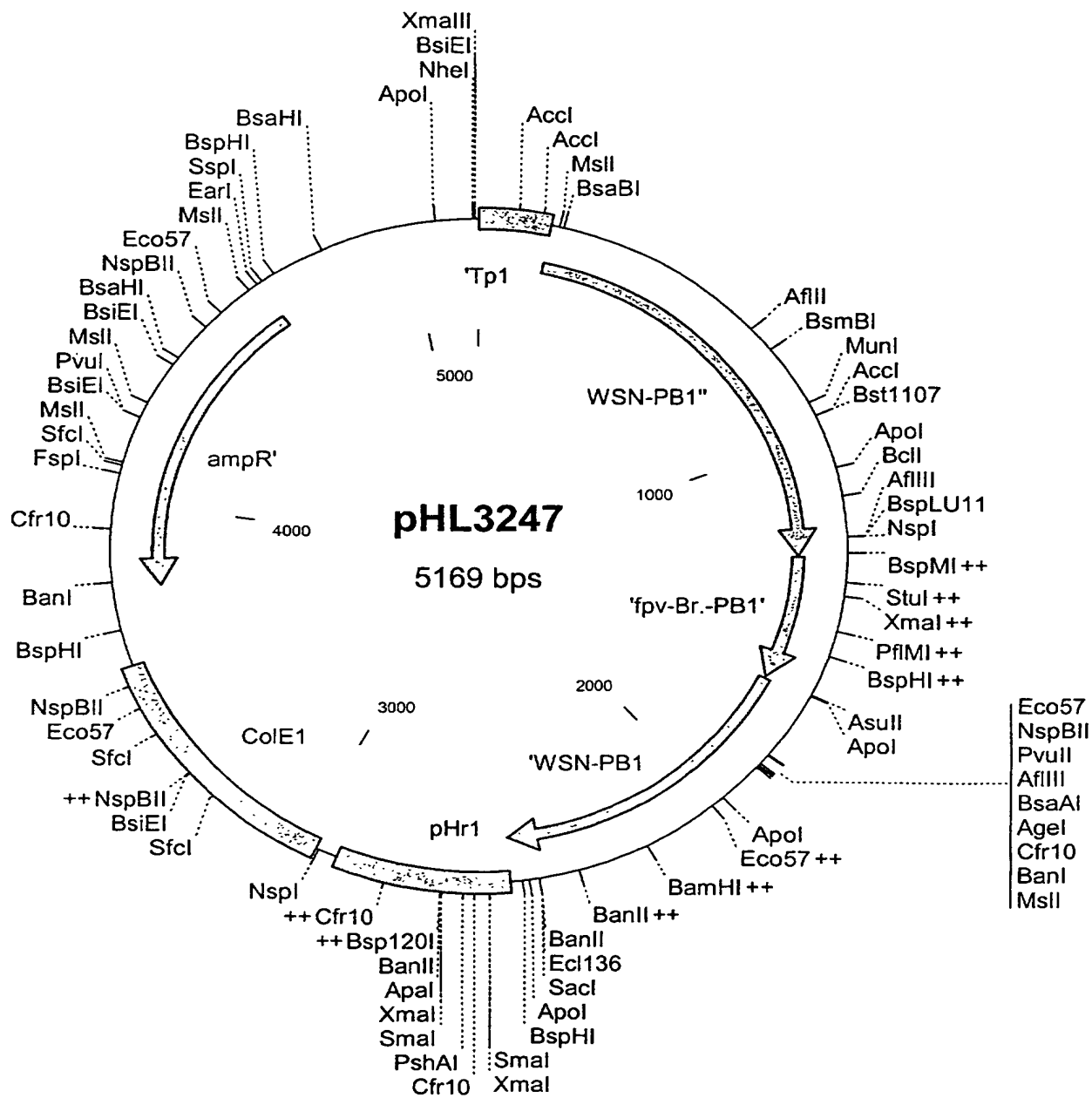


Fig. 14

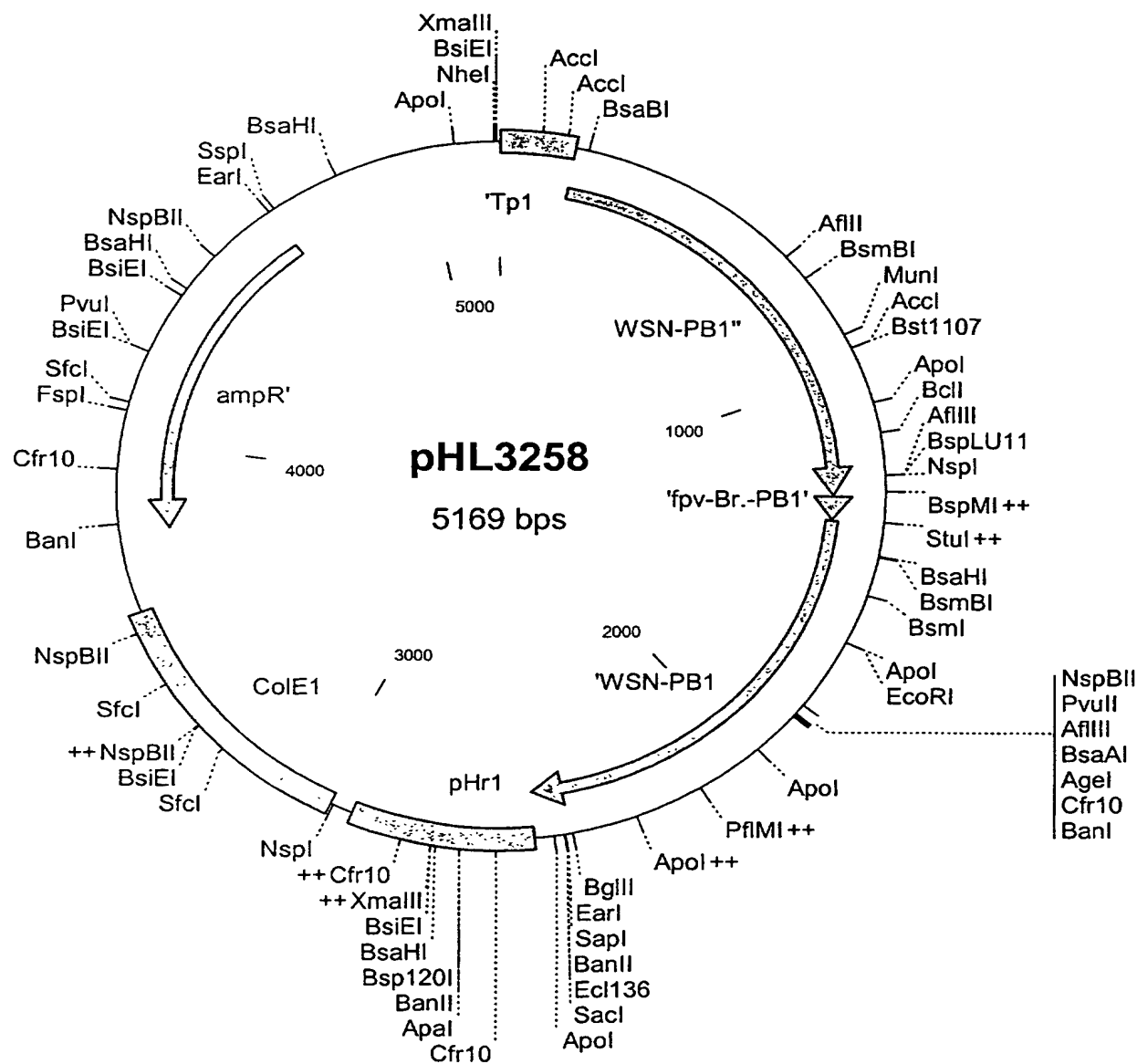


Fig. 15

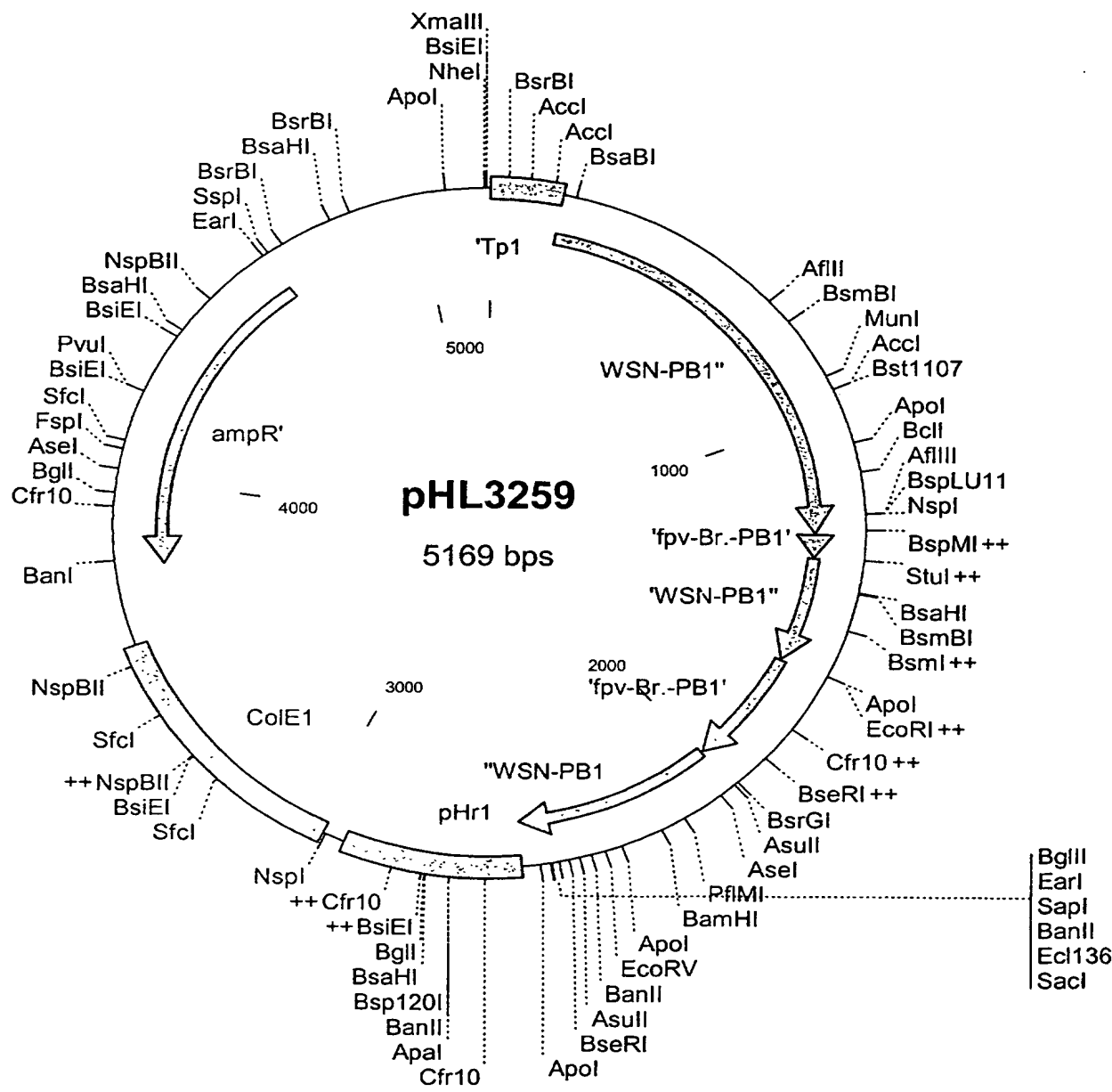


Fig. 16

